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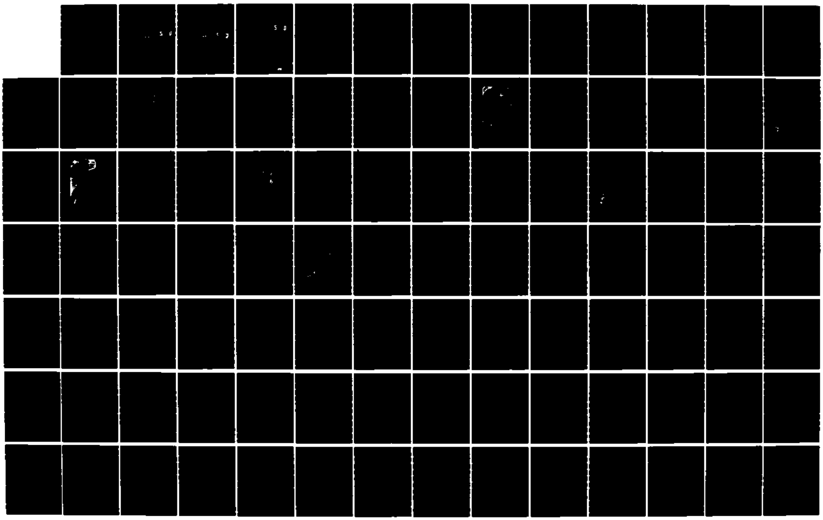

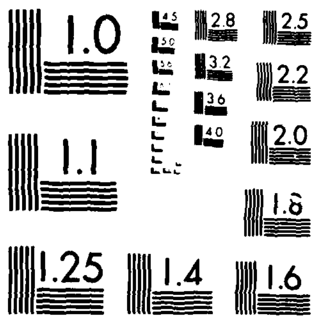
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BOTTOM LOSS UPGRADE (BLUG)
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SHALLOW WATER AREAS: KOREA STRAIT

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# BOTTOM LOSS UPGRADE (BLUG)
# EXTENSIONS TO STRATEGIC SHALLOW WATER AREAS:
# KOREA STRAIT

SAIC-85/1825



September 1985

Prepared
by
William F. Monet
Robert R. Greene

Prepared
for
Naval Ocean Research and
Development Activity
NSTL Station, MS 39529

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This report documents an effort to apply the BLUG methodology to the shallow water acoustic propagation environment in the Straits of Korea. This is a high resolution data base in comparison to the deep water version attributable to the geologic complexity of the environment. The geologic history of this environment is summarized as well as the environmental and geoacoustic parameters used to differentiate geoacoustic areas i.e., sediment thickness, sediment type, roughness, etc. A geoacoustic area chart with documentation

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# Section 1
# INTRODUCTION AND BACKGROUND

The Bottom Loss Upgrade (BLUG)[5,17,24] is a worldwide Northern Hemisphere database of the acoustic properties of ocean bottom sediments. Using nine parameters it characterizes sound speed and attenuation profiles and sediment and basement interface reflectivity. This information is sufficient to calculate the acoustic propagation characteristics of bottom interacting signals for arbitrary source-receiver geometries. It is a conceptual advance over the old-style bottom loss curves which applied to a single measurement geometry and were based on incorrect assumptions about the propagation path. The BLUG database extends our knowledge of the ocean acoustic propagation environment from the water column into the sediment column.

This report documents an effort to apply the BLUG methodology to the shallow water acoustic propagation environment in the Korea Strait. There exists a large collection of geological data for the area, so that the resulting database is of higher resolution than for the original deep ocean database. However, the large number of distinct identifiable geoacoustic areas in the Strait reflects the actual complexity of an environment with strong tectonic and oceanographic effects. The development of the geoacoustic areas was based on quantitative measures of grain size and sediment thickness, as well as qualitative estimates of the roughness of the sediment surface and the underlying basement rock.

The geoacoustic areas are displayed on a chart in Appendix A. A collection of area documentation sheets is

contained in Appendix D. The sheets document the criteria used in determining the area boundaries together with nine parameters which characterize the geoacoustic properties of the sediment. In Appendix B, a summary of the geologic properties of the areas in matrix form is presented. A grouping of the areas by sediment thickness, sediment type and grain size is presented in Appendix C that illustrates similarities among the areas which may be useful in extrapolating the results of acoustic measurements.

The report consists of six sections plus the four appendixes. Section 1 is the introduction; Section 2 discusses the extension of the BLUG methodology to shallow water; Section 3 provides an overview of the physical environment in the Straits of Korea; Section 4 discusses the determination of the acoustic properties of the sediments in the geoacoustic areas; Section 5 contains conclusions and Section 6 is the bibliography.

## Section 2

## EXTENSION OF BLUG TECHNIQUES TO SHALLOW WATER

The extension of the Bottom Loss Upgrade (BLUG) into shallow water involves many of the same analytical techniques employed in the deep water version of BLUG. In this process, provinces are developed which have relatively homogeneous geoacoustic properties. The geologic investigations behind this development involve accumulating and analyzing all available data related to stratigraphy, surface sediments, seismics, bathymetry, regional geology, etc. However, compared to the original development of BLUG, the relative importance of some of these data is shifted. This is primarily due to the modal nature of sound propagation and the generally thin sediments and variable bathymetry in the shallow water environment. The more important of these criteria for the determination of geoacoustic areas in shallow water are:

- surface sediment type and grain size,
- sediment thickness,
- basement roughness,
- sediment surface roughness at the water-sediment interface, and
- bulk sediment properties (i.e. layering, etc.).

The methodology followed for assembling these data to generate geoacoustic areas in the Korea Strait is described here.

The surface sediment type, grain size and sediment distribution were determined from several sources: the

Hydrographic Department of Japan, the Republic of Korea Army Map Services, Geological Survey of Japan, National Science Museum of Japan, NAVOCEANO and others. The nomenclature used to describe the sediments varied widely depending upon the authors, therefore it was necessary to standardize these terms to one set. The chosen nomenclature was that of Shepard,[23] incorporating the Wentworth scale for the various grades of sand, principally to be consistent with Ed Hamilton's[6] work on the empirical relationship between the physical and acoustic properties of sediment.

Each of these charts and maps was projected to the same scale as the bathymetric base map provided by NAVOCEANO (Figure 1) and transferred to Mylar for overlays. Information relating to sediment type and sediment thickness was consolidated into the respective charts. Information on sediment type was available in the form of regional charts and sediment core data. Where regional boundaries and the distribution of core data agreed, a line was drawn to isolate that region. However, there were inconsistencies between various sources; for instance, many of the charts used displayed unconsolidated sediment where others displayed rock (or basement) outcrops in the same location. Where disagreements occurred, the final boundaries were biased toward the best supporting data or most reliable charts and data.

A second chart was generated consolidating the various sediment thickness (isopach) maps in conjunction with seismic data into areas based on the following criteria:

1) basement outcrop or shallow sediment structure,
2) sediment thickness between 0 and .25-sec two-way travel time
3) sediment thickness greater than .25-sec two-way travel time.

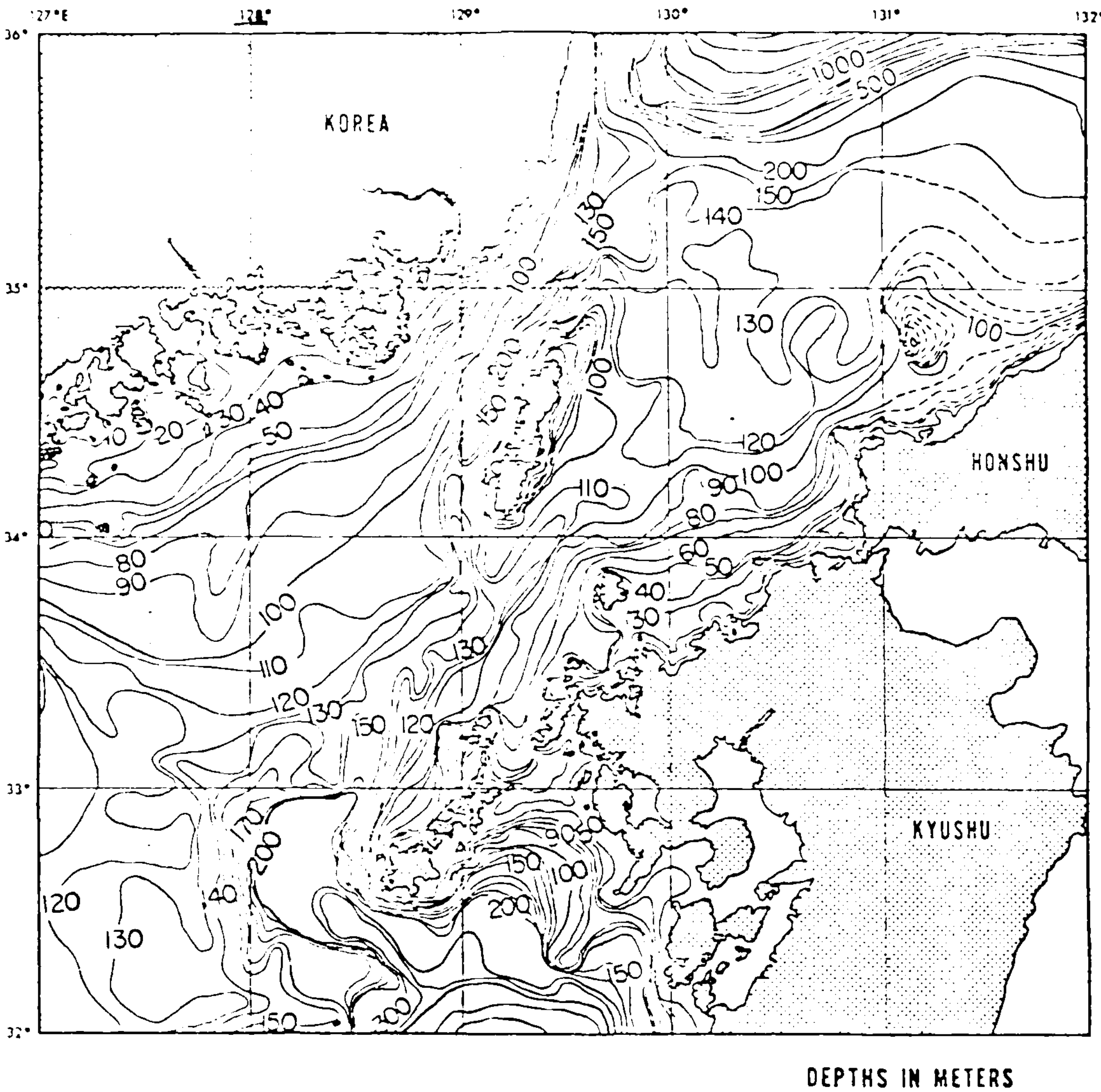



Figure 1. Bathymetry for the Korea Strait (from NAVOCEANO)[2]

These categories were based on calculations used to determine the depth to which a sound wave, at normal incidence, would propagate into the sediment.

A final BLUG area chart was created by intersecting the intermediate charts, based on sediment type distribution and sediment thickness, respectively. The area boundaries on this final chart were fine-tuned to incorporate data concerning structural lineations, bathymetric data, layering, and any other physical data that might impact the acoustics of an area.

An area documentation sheet characterizing the geology and estimated geoacoustic properties was developed for each area. The geoacoustic areas developed for the Korea Strait are displayed in a chart in Appendix A. Documentation sheets for each area, associated by area number, are contained in Appendix D. The sheets record the physical environment, a description of the relevant geoacoustic characteristics of the area and a list of the assigned geoacoustic parameters.

## Section 3
## PHYSICAL ENVIRONMENT OF THE KOREA STRAIT

### 3.1 Geography

The Korea Strait (or Tsushima Strait) is located on the east coast of Asia between the peninsula of Korea to the west and the islands of Japan to the east (Figure 2). In the north it borders the Sea of Japan and in the south the East China and Yellow Seas. The major islands located in or near the strait are Cheju, Tsushima, Goto and Iki. There are numerous smaller islands strewn along both the Korean and Japanese coast lines which collectively make for a highly irregular margin. Tsushima is one of the more obvious features in that it lies in the middle of the strait, dividing it into two separate channels. Cheju is a large mountainous island south of Korea which is apparently linked in its structural geology to Korea and mainland China. The Goto and Iki Islands are similarly linked along a structural trend. The Goto Islands form an arc with the Japanese Island of Kyushu, isolating the Danjo Basin from the Korea Strait.

The geographic limits of this study are approximately 32°00'N to 35°30'N latitude and 126°00'E to 131°15'E longitude.

### 3.2 Regional Geology

The Korea Strait is part of a very complex trench-arc-back arc system characteristic of the western margin of the Pacific. The major features seen in this region are a result of the collision of oceanic and continental plates

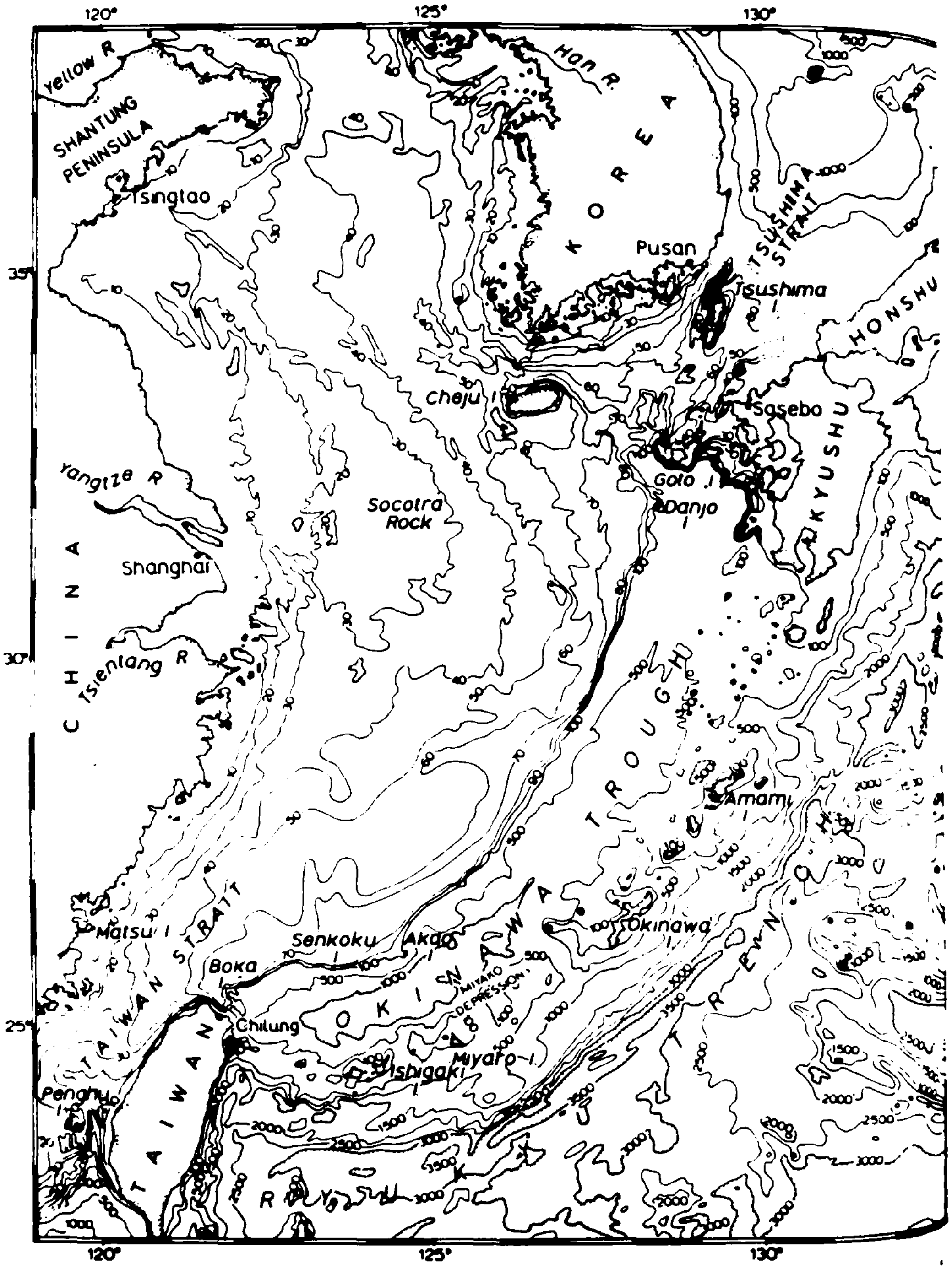



Figure 2. General topography and geography surrounding the Korea Strait (from Wazeman, et al.)[24]

(Figure 3). The oceanic plate in this case is being subducted, or underthrusted, beneath a continental slab along an oceanic trench; namely, the Philippine Plate along the Ryukyu Trench south of Japan and the Shikoku Plate along the Nankai Trough off Japan (Figures 4 and 5). At present the major physiographic provinces are:

1) The continental shelf - the northern portion of which floors the Korea Strait with a width of about 150 km between Korea and Japan.[29] It extends south along the mouth of the Yellow Sea to mainland China and beyond Taiwan. The shelf-break roughly coincides with a 120-m contour line. Most of the shelf is shallower than 100 m (averaging ≈ 55 m) and slopes seaward more or less continuously to the shelf-break.[16]

   The Tsushima Shelf has undergone block movement during Neogene time (~ 23 M.Y.B.P.) but no back-arc spreading has been noted.

2) The trough-ridge-trench terrain - which is known as the Nansei Shoto Trough, Ridge and Trench. This includes the Okinawa Trough, the Ryukyu Ridge, and the Ryukyu Trench. North of the Ryukyu Ridge and Trench is the Seinan Japan Arc, including the islands of Honshu, Shikoku, and most of Kyushu (the southern portion of Kyushu is the northernmost expression of the Ryukyu Arc), and the Nanhai Trough east of Japan.

3) The Tsushima Basin and Japan Sea - these environments are north of the Korea Strait,

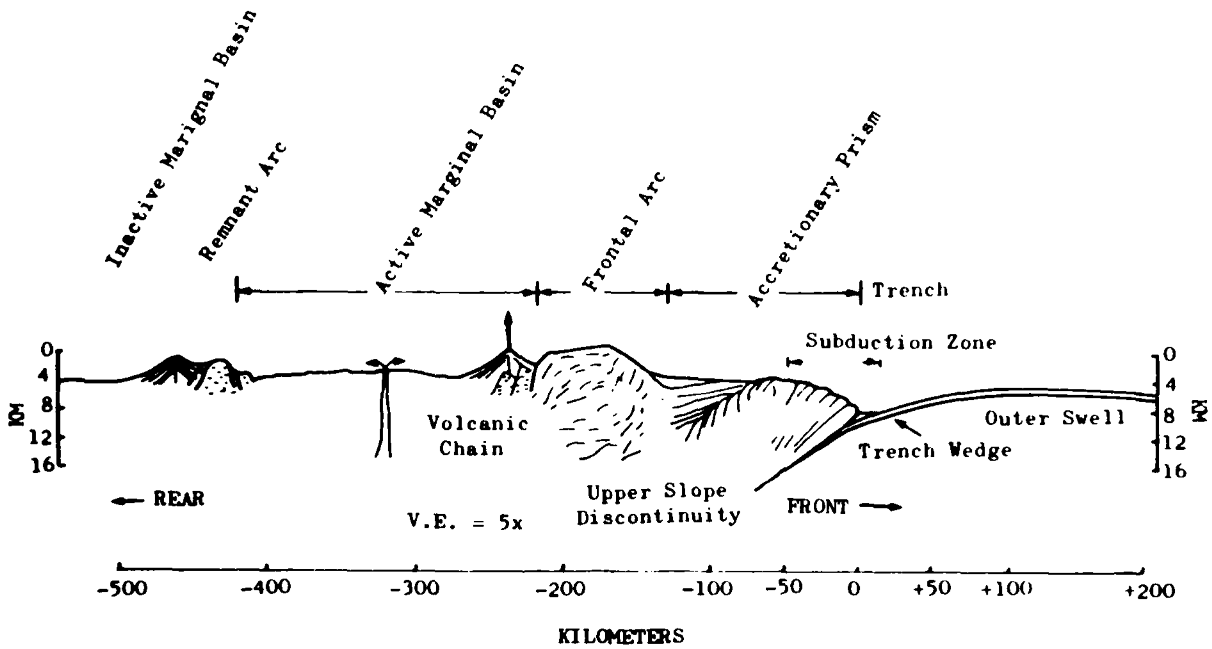



Figure 3. Generalized framework of a western Pacific island arc system (Karig, 1974)

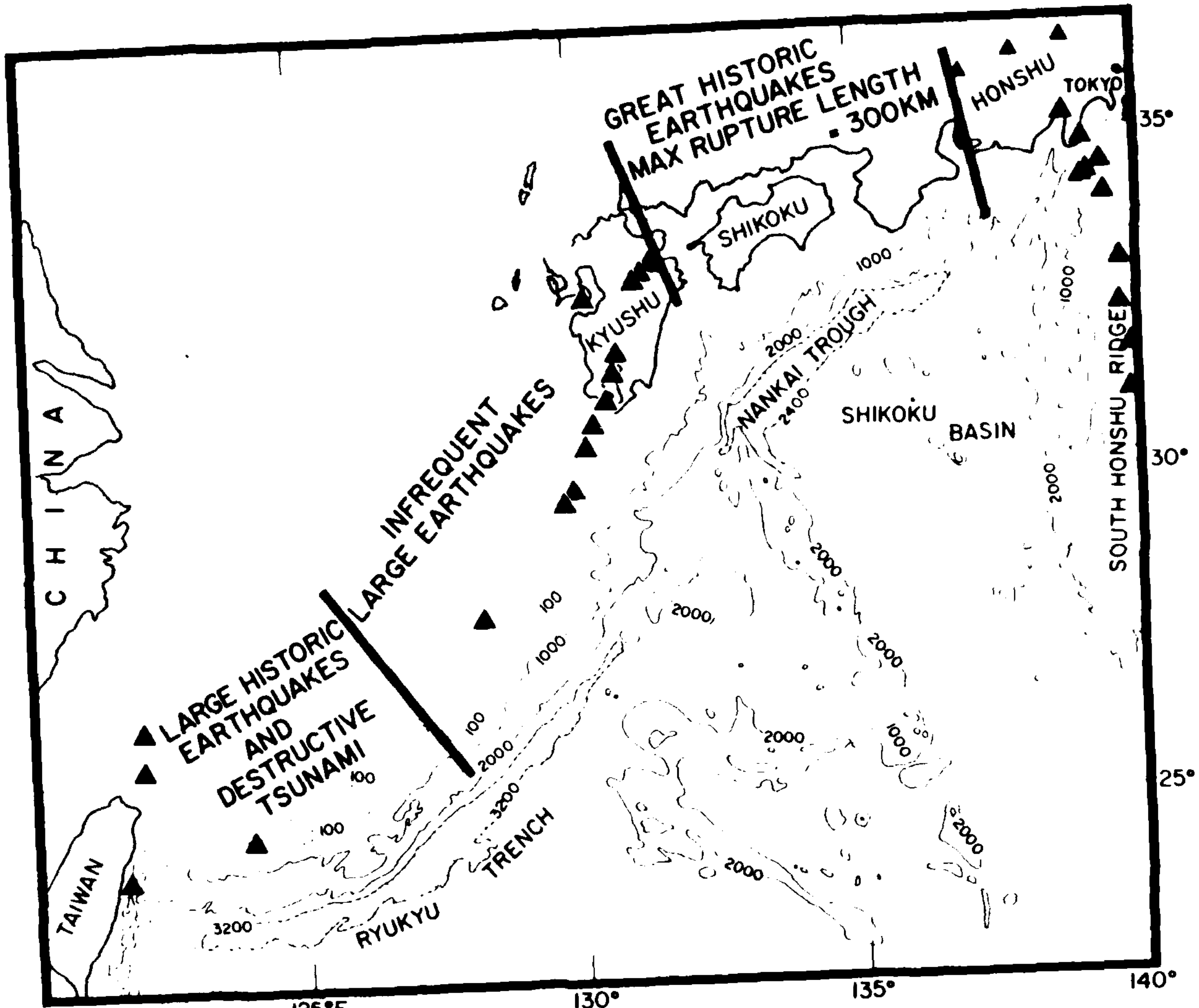



Figure 4. Earthquake and volcanic activity along the Ryukyu and Seinan Japan Arcs (from Talwani, et al., 1977)[20]

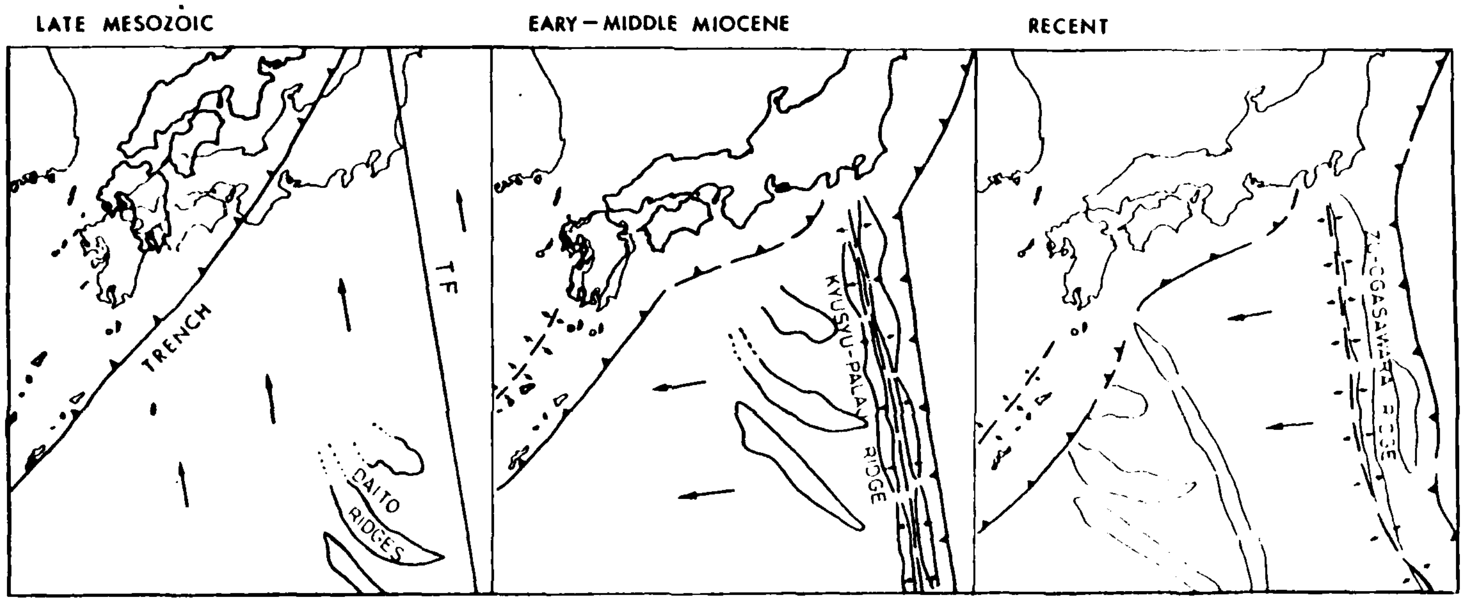



Figure 5. Relative plate motion around the Japan and the ıikoku Basin (Honza, 1978)[8]

beyond the shelf-break, and have little influence on the study area.

### 3.3 Tectonic History:

The peninsula of Korea is not mountainous, having only a few peaks higher than 1500 m, and has a structural trend of NE-SW. The west coast of Korea is low and consists of coastal plains, small hills and many rocky islands. The islets off the southern tip of Korea represent drowned portions of the hilly mainland coast. The small island of Cheju further to the south has a mountain peak higher than any in Korea. This trend of hilly terrain has been noted by bathymetric surveys which show submerged hills extending offshore to the southwest to Shanghai, China.[20] This is part of the Fukien-Reinan massif that was uplifted during the middle to late Mesozoic Era forming an arcuate barrier to the Yellow Sea and Gulf of Pohai (Figure 6).[29] Evidence for this comes from exposures of bedrock including olivine basalt off Shanghai and sandstone east of Cheju Island which support the presence of a former arcuate connection between Korea and south China.[20] This barrier isolated the Yellow Sea from the ocean until the end of the Cretaceous Period ($\approx$ 65 M.Y.B.P.). There exist only nonmarine strata on land of Cretaceous age northwest of the massif, but they are several thousand meters thick. This barrier was breached during the Paleogene ($\approx$ 65 to 23 M.Y.B.P.) where there is evidence of thick accumulations of sediment, especially during the Neogene. These large accumulations were probably due to the damming of these mostly land derived sediments by the uplift of the Taiwan-Sinzi folded zone during some of the Paleogene and throughout the Neogene (Figure 6). This process built the enormous continental shelf associated with the Yellow and East China

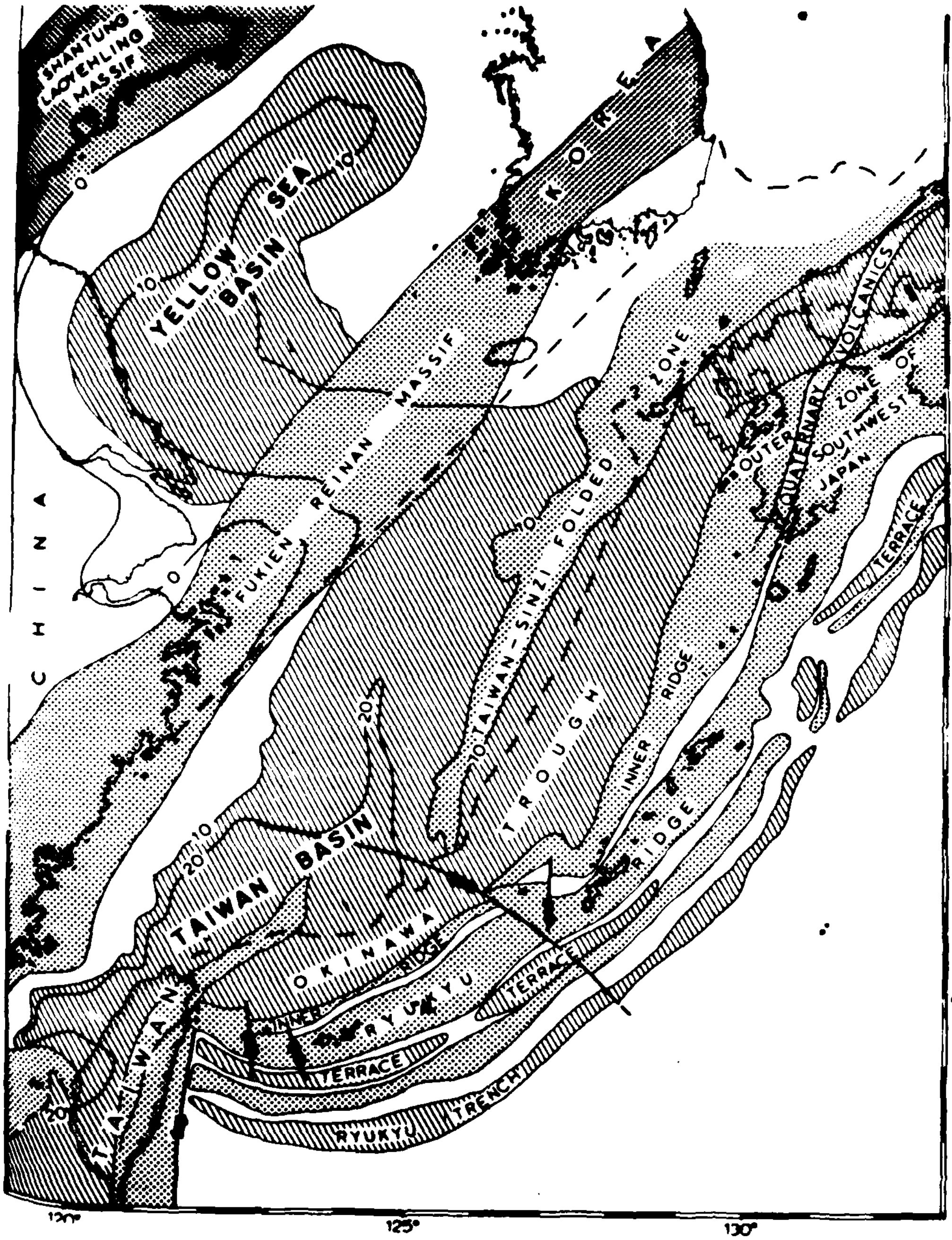



Figure 6. Major structural zones of the East China Sea and vicinity (Wazeman, et al.)[24]

Sea,[21] varying in width from 230 to 460 km with the maximum being about seven times the world average.[16]

Today the Yellow Sea is filled with sediments derived from the Yangtze and Hwangho rivers and the middle portion of the Fukien-Reinan massif forms a flat, shallow sill at the entrance to the Yellow Sea.[20] This sill extends north and appears as outcrop on the island of Cheju and the small islands bordering Korea. The Fukien-Reinan massif may also form the basement rocks flooring the west channel of the Korea Strait. The Taiwan-Sinzi folded zone forms the eastern border of the continental shelf and the western flank of the Okinawa Trough. It extends northward and can be seen in outcrop on the Goto Islands south of Japan. Here it consists mainly of Tertiary folded sedimentary and acidic intrusive rocks. This zone of folded rocks forms the basement found beneath the Eastern Channel of the Korea Strait and also outcrops on the Island of Tsushima.[29]

Refraction measurements conducted by the Geological Survey of Japan have indicated differences in basement velocities on either side of the western depression of the Tsushima Island. This suggests that the tectonic boundary between the older Seinan Japan Arc and the Korea Continent runs locally along this depression in a NNE-SWW direction and turns to a NEE-SWW direction along the northern margin of the Tsushima Basin.

East of the shelf-break and the eastern flank of the Taiwan-Sinzi folded zone there is a dramatic change in topography beginning with the Okinawa Trough. The axis of the trough extends in a NNE-SSW direction with the northern border terminating at the juncture between the Goto Islands,

an outcrop related to the Taiwan-Sinzi folded zone, and the volcanic rocks of the Ryukyu Arc. The slopes of the trough consist mainly of sedimentary rocks. This region is also complexly folded and faulted and basement ridges exist at shallow depths. A fault origin is suggested by the numerous faults located on the flanks of the trough. These faults cut upper Neogene deposits on the slopes, indicating very recent tectonic motion. A concentration of epicenters in the trough region also support tectonic motion.

The Ryukyu Ridge is the next feature to the east of the Okinawa Trough. It is an elongated feature consisting of volcanic and folded sedimentary rocks, both seen in outcrop on the many islands along the arc, including Okinawa, and in southern Japan where the volcanic fold of the arc takes a sharp bend and becomes the Seinan Japan Arc. It is suggested that the Ryukyu Arc and the Seinan Japan Arc began their activity in the *Miocene* (23 to 5 M.Y.B.P.). This was followed by subduction along the trenches (on the Pacific margin), volcanism, and deepening of the basins along the inner (landward) side of the arc.

The "volcanic front", located to the east of the tectonic boundary, on both the Seinan Japan and Ryukyu Arcs is located on a slightly different zone (Figure 7). If these Arcs were part of the same arc system in their early stages then the difference in tectonism of the later stages must be due to a difference in the conditions of subduction. Two possible explanations are: 1) that there existed a difference in the material being subducted under the arc. This could have occurred during the formation of the Shikoku Basin caused by the shift of the Ozasswara Arc, or 2) by a change in subduction angles of the plates beneath the arc.[10]

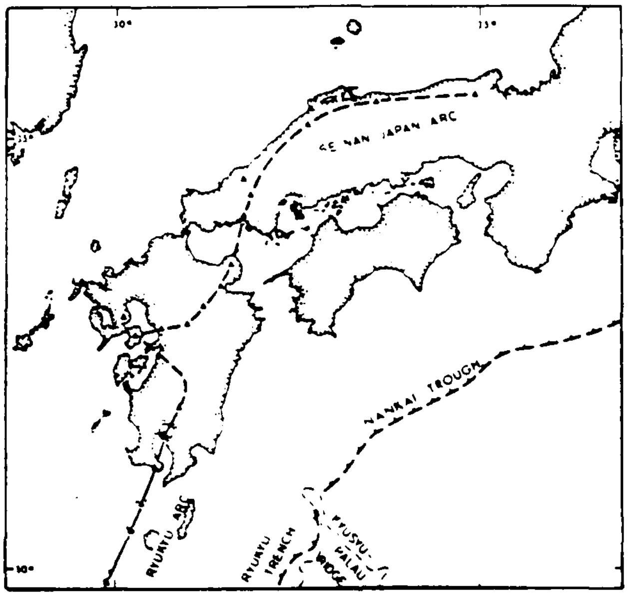



Figure 7. Volcanic front in the northern margin of Ryukyu Arc and in the Seinan Japan Arc (Honza, 1978)[8]

The ridge contributes very little sediment to the Korea Strait, except possibly in the form of volcanic ash accounting for some of the layering seen in the area, and is therefore only included in this discussion for completeness.

## 3.4 Stratigraphy

In general there appear to be three lithologic units in the Yellow Sea and continental shelf. The lowest, and oldest of these units is opaque to acoustic energy and is considered to be acoustic basement. The acoustic returns as seen on seismic records are strong noncoherent echoes with numerous hyperbolic reflections indicative of a rough surface. The second and third units appear from the echo character to be well-stratified sedimentary facies. The second layer is usually found ponded between basement highs and appears to have been structurally deformed and later eroded. The second and third layers are separated by an angular unconformity which also truncates the basement highs. This unconformity undulates from less than 300 m below the sea floor to approximately 1400 m with a wavelength of about 300 km.[21] Since the unconformity cuts both layer two, or the predeformation layer, and the basement, it is thought that the unconformity occurred after the regional orogenic event of the mid-Tertiary. The predeformation deposits are thought to be Paleogene or older.[29]

Layer one, or the postdeformation unit, is widespread over the continental shelf (Figure 8). It is well-layered, exhibiting numerous horizontal reflecting horizons, except above basement hills where the beds dip slightly due to differential compaction. Layer one is Neogene in age as indicated by samples collected from outcrops on the Goto

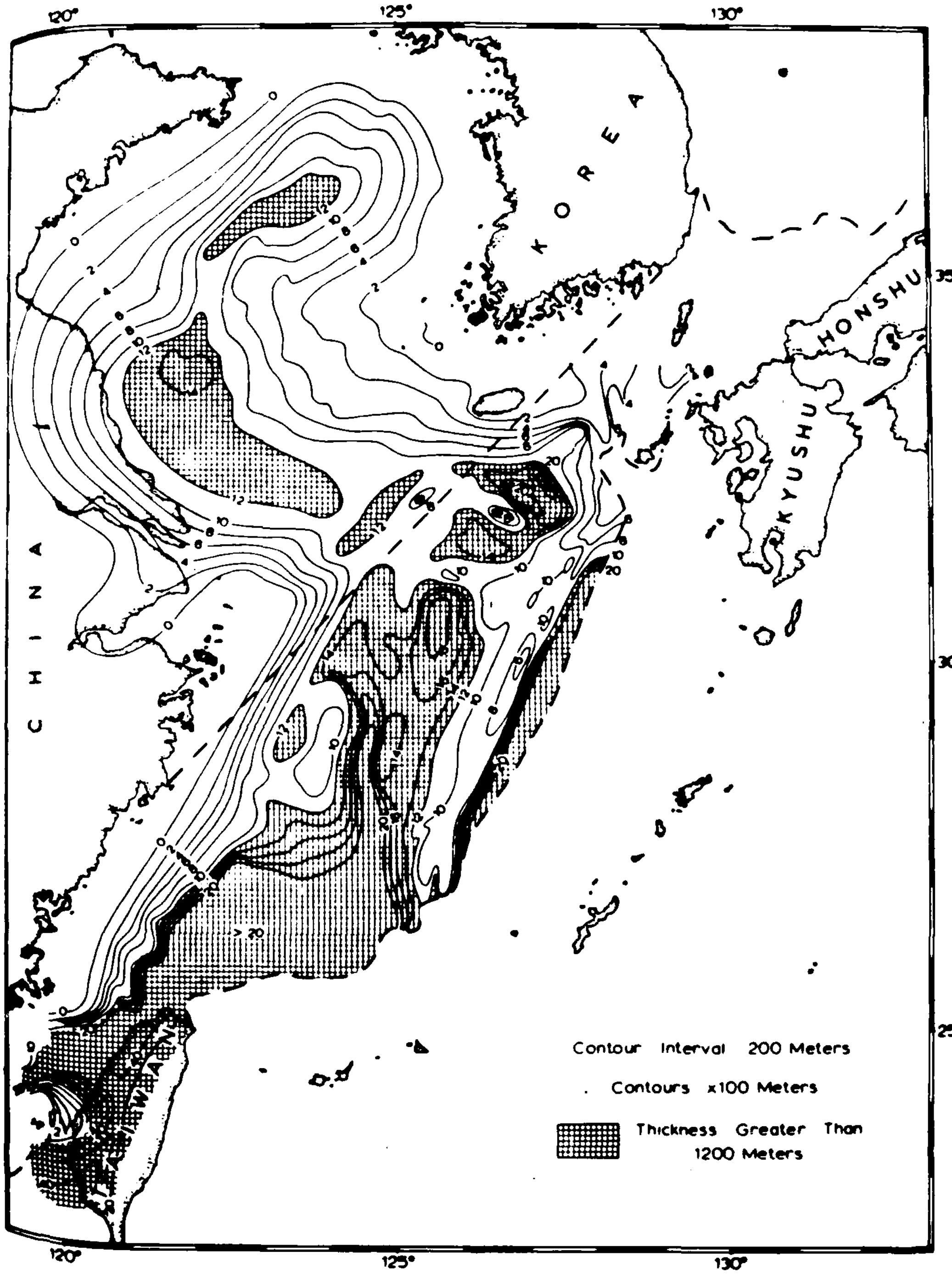



Figure 8. Isopach map of post-depositional (Neogene) facies beneath Yellow Sea and continental shelf (Wazeman, et al., 1978)[24]

Islands near Kyushu, Taiwan and from dredge samples on the shelf between Taiwan and Japan. These deposits get very thick toward the southern portion of the continental shelf (> 2000 m), but thin markedly in the Strait (< 400 m).

## 3.5 Sedimentation

The sediment found on the continental shelf is generally distributed as silt on the nearshore portion and sand further offshore (Figure 9). Modern deposits are supplied by the Yangtze and Hwangho Rivers in the Yellow Sea and are mostly carried south along the coast of China by the inshore southwest-flowing current.

There is a tremendous amount of suspended sediment associated with this current, primarily from eroded loess of western China. This gives the water its yellow color. Most of the suspended sediment is inorganic nearshore which accounts for the dominance of silt sized sediment. A small portion of the fine grained sediment is transported north and eventually along the west coast of Korea, with some sediment spilling around the southern tip of Korea.

The primary source of sediment on the outer shelf is controlled by the large amounts of dissolved nutrient salts in the river water which in turn leads to active growth of microscopic algae in the surface waters. The result is greater accumulations of organic-rich deposits in the Yellow Sea and outer shelf. This process was probably continuous throughout the Cenozoic and may account for the thick accumulation of fine-grained, organic deposits found in the Yellow Sea.

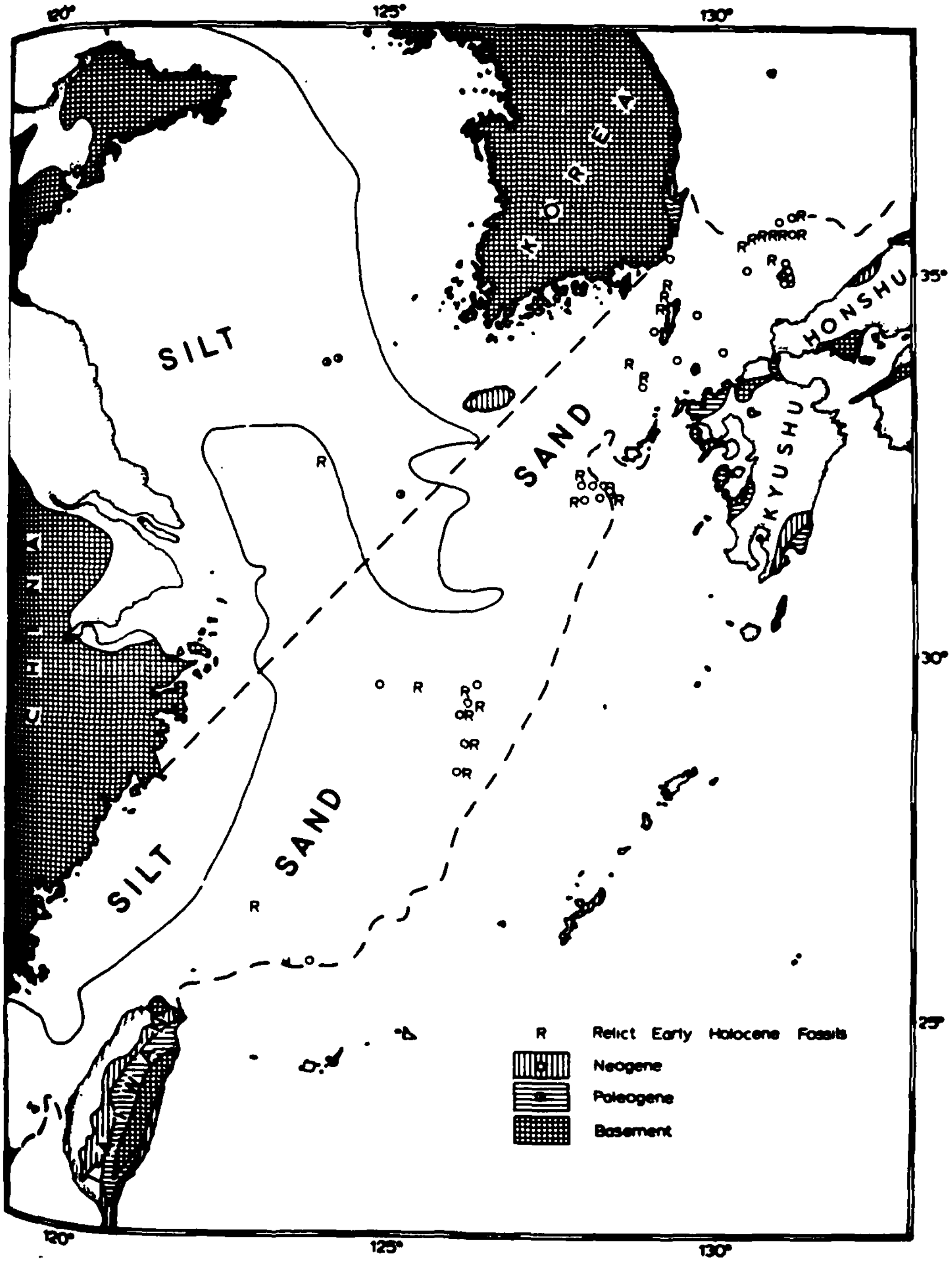



Figure 9. Generalized pattern of unconsolidated sediments and positions of numerous fossils relict from early Holocene low stands of sea level (Niino and Emery, 1961; Wang, 1961)[17,25] (from Wazeman, et al.)[24]

The dominant current in the region is the warm, north flowing, high-salinity Kuroshio current. It is similar to the Gulf Stream in that it maintains a meandering pattern[26] shifting laterally several hundred kilometers. Most of the water moves eastward out of the region just south of Japan, but one branch, the Tsushima current, enters the Japan Sea through the Korea Strait, mostly during the summer when the current is widest and fastest (Figure 10). While the Kuroshio is weakest during the winter, the inshore southwest-flowing current is best developed, consisting of cold low-salinity water partly derived from the large rivers.[20]

The sands found on the outer half of the shelf, including the Korea Strait, are predominantly calcareous (averaging about 30% $CaCO_3$) and are iron stained. This type of deposit is common to many continental shelves around the world which have remained unburied since the glacially lowered sea levels of the Wisconsin stage (Emery 1968). The relict texture of these deposits was confirmed by NAVOCEANO when they examined 32 cores and found them to contain the remains of land mammals, brackish-water mollusks, and shallow marine mollusks (Figure 9). Radiocarbon dating of 15 of the samples range from 4,000 to 30,000 years (Emery et al).[29]

The Japanese Hydrographic Office has published 53,000 samples with notations of bottom material which adhered to the tallowed lead used in early hydrographic surveys prior to 1841. These data were compiled into bottom-sediment charts by Shepard, Emery and Gould (1949)[30] (Figure 11). Some of the general trends noted on these charts have been confirmed by later investigations. Rocky bottom can usually be seen outcropping in straits, atop submarine hills,

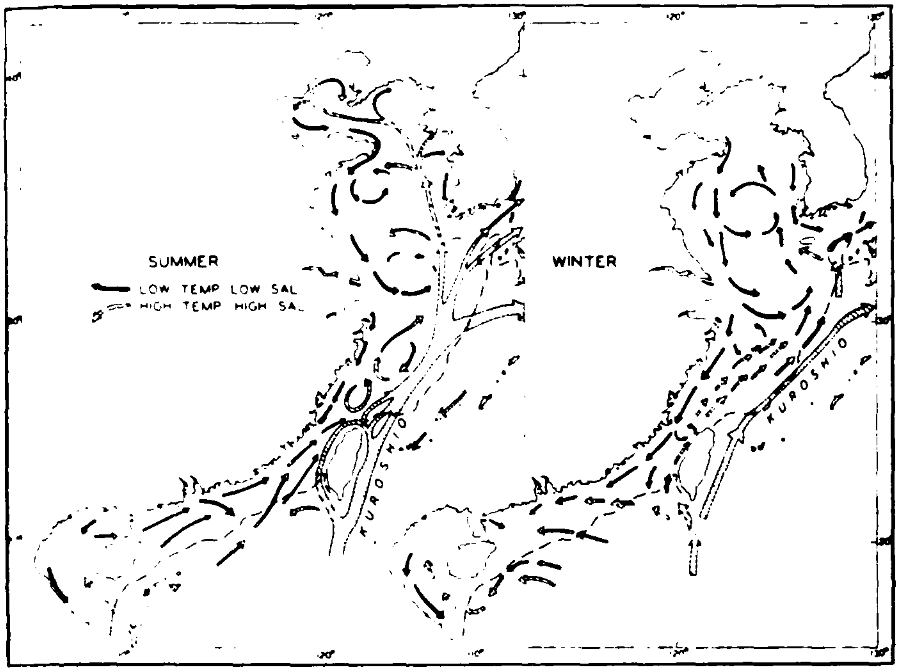



Figure 10. Surface currents, summer and winter (Niino, 1961)[17]

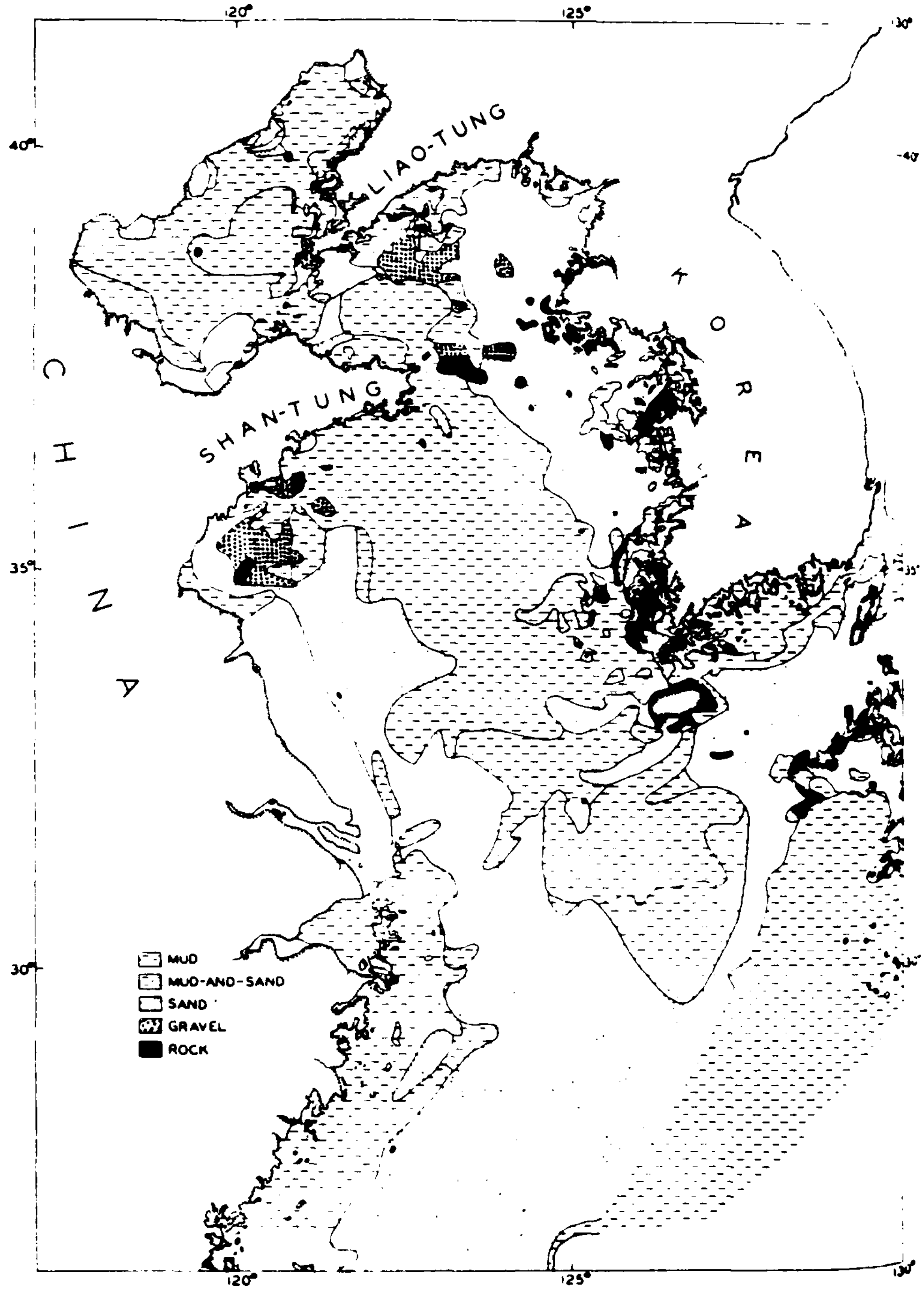



Figure 11. Regional sediment distribution in the Yellow Sea, East China Sea, and Korea Strait (Niino, et al. 1961 and Shepard, 1949)[17,19]

off rocky points and islands and near the shelf-break. A thin veneer of gravel usually overlies the rocky bottom as a result of winnowing of the finer sediment by strong currents and wave action. Muddy sediment, such as clayey silts and silty clays, are located close to the shore of Korea and in the shadow zones northeast of the Tsushima and Iki Islands, away from the erosive currents in the central portion of the strait. Sand sized sediment dominates the Korea Strait proper. Sand or shell sand, in the medium to fine sand range, covers the majority of the strait, even in the Tsushima Trough. These deposits show a moderate skewness toward the fine side. Sands are dominantly coarse between the Iki and Tsushima Islands.[27]

Studies relating stream velocity to sediment transport, after Hjulstrom (1939),[8] were conducted by the National Science Museum of Japan in the Korea Strait. The bottom-water velocity was derived from surface-water velocity and extrapolated to the sea floor. The water is relatively shallow and this is therefore a close approximation. The result of plotting the grain size of all the sampled stations on a Hjulstrom diagram indicated that all the stations, except one, fell in the regions of transport or erosion (Figure 12).[27]

The scouring affect of the Tsushima Current therefore affects the bottom configuration and sediment distribution in the straits. The bottom relief of the eastern channel is mainly smooth and even except for some minor rises and grooves with a NNE-SSW trend. The western channel however is characterized by a deep trough, the Tsushima Trough, adjacent to the island of Tsushima. The eastern wall of the trough is extremely steep while the western wall has a

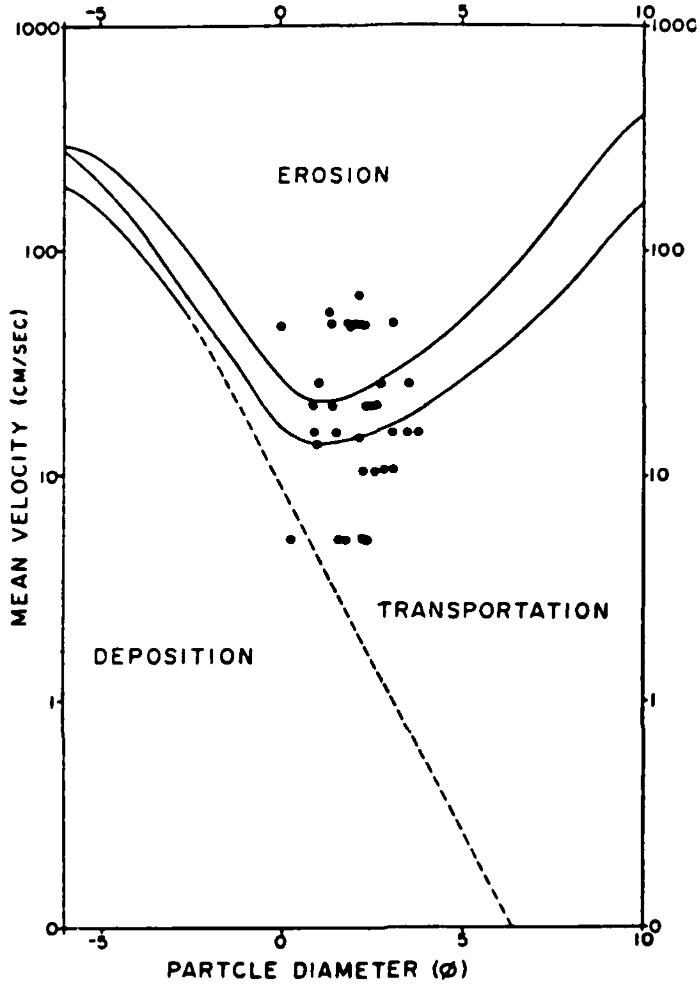



Figure 12. Relationship between particle diameter and mean velocity of flowing water (after Hjulstrom, 1939)[6], tentatively plotting median diameter of sediment and approximate surface-velocity of the Tsushima current estimated at 34 stations of the Korea Strait[22]

gradual slope rising to a shallow bench surrounding the southern coast of Korea.

The northern portion of the Okinawa Trough, or the Danjo Basin, is exposed to different flow and depositional conditions than exist in the straits. Sediment is supplied to the head of the trough by slumping and sliding and transported via turbidity currents to the deeper areas of the trough to the south. Deposits can exceed 1.2 km with numerous reflecting horizons attributable to turbidites and ash layers. The layering is generally concave-up due to differential compaction and/or continuing downwarping. The layering is discontinuous up the flanks of the trough and becomes highly disturbed as a result of slumping as the trough shoals to the north.

The small basins and inlets disecting the west coast of Kyushu are floored by fine- to medium-grained deposits with minor amounts of sand.

## 3.6 Sediment Thickness and Basement Roughness

Sediment thickness data are sparse for the Korea Strait. The majority of data was obtained from investigations conducted by the Hydrographic Department of Japan by Nazano, et al., off the west coast of Nyushu in 1973 and 1974. These data were examined first by Allen Lowrie of NAVOCEANO (personal communication) who, using the continuous seismic profiles, contoured regions of sediment separated by isopleths indicating .25-sec two-way travel time, .50-sec two-way travel time and areas of basement outcrop. The surveyed area lies west of Kyushu and south of Tsushima, and therefore did not cover the entire area of interest.

Other sources of sediment thickness information were provided by Sadanari and Cesanuma of the Department of Science and Technology, National Science Museum, Tokyo.[14] These data were lacking in detail and only illustrate gross trends in sediment thickness. This is also true with the impact maps produced by Marucki, et al. (Figure 13) and Wazeman et al. (Figure 14).[2,21]

The majority of the basement in this region appears to be rough as would be expected in a tectonic setting such as this. The west channel of the Strait is smooth relative to the east channel with the exception of the Tsushima Trough. The angular unconformity (erosion surface) discussed under stratigraphy is mainly smooth and may be a prominent reflector above basement rock.

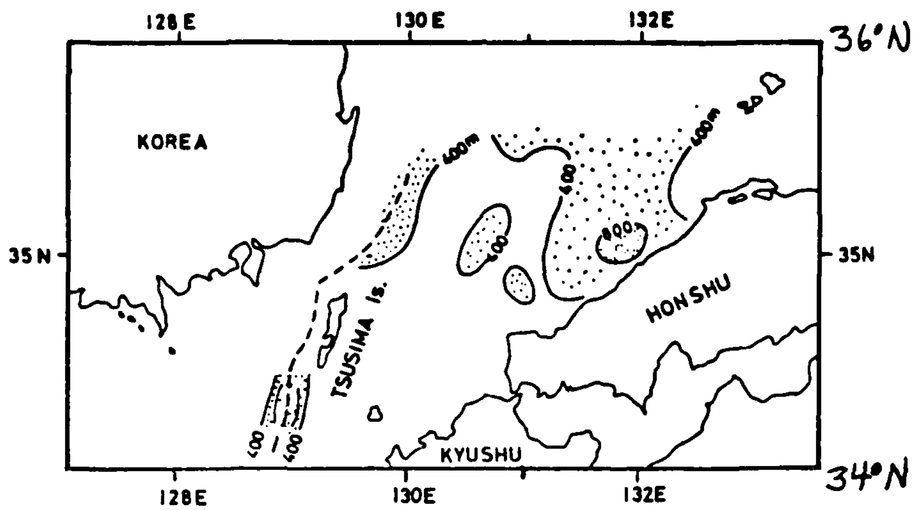



Figure 13. Isopach map of unconsolidated sediments. Dotted areas are covered by the unconsolidated sediments thicker than 400 meters. Broken line shows the axis of presumable Tsushima Trough (Murauchi, et al., 1969)[15]

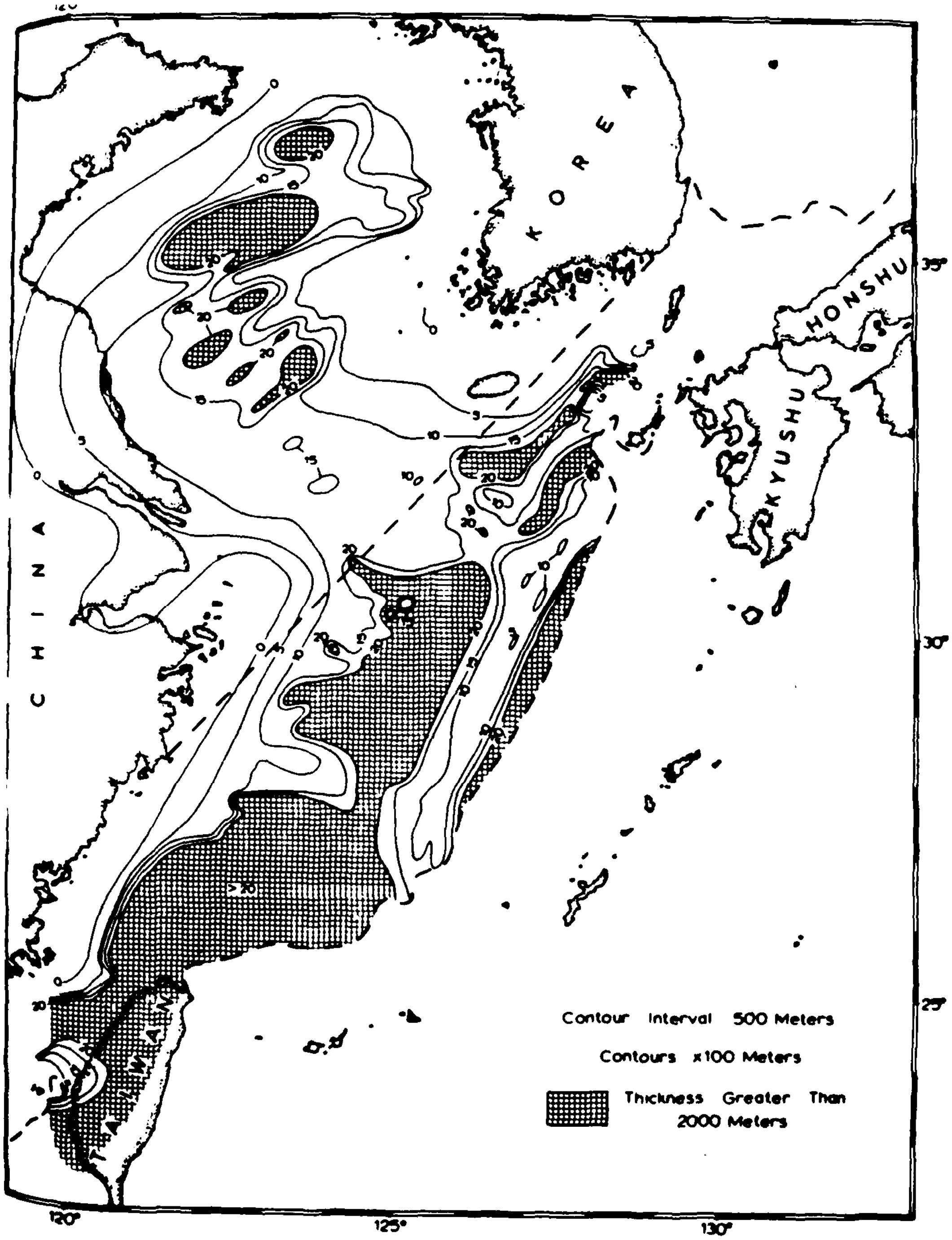



Figure 14. Isopach map of total sedimentary column overlying acoustic basement in Yellow Sea and continental shelf (Wazeman, et al.)[24]

## Section 4
## THE DETERMINATION OF ACOUSTIC PROPERTIES

The geo-acoustic properties of the sediment in the Korea Strait have been specified by eight of the parameters of the original deep-water-BLUG database.[24] These parameters characterize the acoustic sound speed profile, attenuation profile, and reflectivity of the sediment. Rather than specifying a reflection coefficient for the underlying basement rock, the ninth parameter of the original BLUG data base, representative values of the compressional ($v_p$) and shear ($v_s$) speeds and density of the rock are specified, which can be used to calculate a reflection coefficient.

The primary sediment properties governing acoustic propagation in shallow water are those relating to sediment reflectivity. Acoustic propagation in the shallow water environment is modal in nature. Because the sediment is a lossy propagation medium compared to the water column, the best propagation characteristics occur when the ocean sound speed profile and the geo-acoustic properties of the bottom combine to trap acoustic modes in the water column. This occurs, for high enough frequency, when the sound speed profile is upward refracting. In addition, when the sediment has a higher sound speed than the water column, the sediment will be totally reflecting, producing additional trapped modes in the water column. Extreme range dependence or roughness in the ocean-bottom interface can counteract the effects of a high speed bottom, producing mode conversion to lossy propagation modes.

The reflectivity of the water-sediment interface in this report is characterized by the sediment sound speed ratio

with respect to the water column and the sediment density ($\rho_3$). These values were estimated for the database, based on the sediment grain size and type, using Hamilton's[6] empirical grain size-sediment property relations. Thus the values represent the actual physical properties of the sediment.

The effect of the so-called "stainless steel layer" that is commonly observed in abyssal plains of the deep ocean, is expected to be unimportant in shallow water because the sediment is generally too thin to contain many layers, and bathymetry is too variable in range to produce strong coherent reflections. In abyssal plains, the effect is due to the strong reflectivity of thick beds (hundreds of meters) of thin, flat-lying layers approximately one meter thick. The thin layer effects have been suppressed for the purposes of BLUG extraction calculations be setting the thin layer density ($\rho_2$) equal to the bulk sediment density ($\rho_3$). The layer thickness (D) is set to a nominally small value of .04 m.

The parameters for the sound speed and attenuation profiles in the sediment are the same as those used in the original BLUG shallow water area, Area 0. The sound speed profile parameters, the gradient at the surface of the sediment ($g_0$) and a profile curvature parameter ($\beta$) were chosen to give a good match to Hamilton's published sound speed profile for sand.[6] The parameters for the attenuation profile, an initial value at the surface of the sediment ($k_0$) and a constant gradient ($k_0'$), were chosen to match Hamilton's[6] graphical data for attenuation in shallow water, near the surface of the sediment. An unfortunate complication of this attenuation profile in shallow water is that the gradient is negative, leading to negative values of attenuation below a depth of 500 meters. The actual profile decreases from .3 dB/m/kHz at the surface to a value of about .15 dB/m/kHz at a depth of 250 m and at greater depths continues to decrease at a much reduced rate. This profile cannot be adequately

modeled by the two-parameter linear profile in the original deep-water-BLUG data base. To compensate for this shortcoming, the sediment thickness in the Area 0 shallow-water province of BLUG was set to an artificially low value of .2 sec two-way travel time, which corresponds to about 160 meters. For the Korea Strait region considered in the report, the sediment is generally less than 500 meters thick, so no anomalous effects will be observed due to negative attenuation artifacts. However, if the database is used in areas where the sediment is greater than 500 meters thick, it is suggested that the attenuation decrease to a level of .15 dB/m/kHz at 250 meters depth and then assume that constant value for greater depths.

A highly reflective basement rock underlying the sediment can trap additional propagating acoustic modes. These modes contribute more to the overall propagating signal when the sediment is thin and the frequency is low. Once again, extreme roughness of the sediment-basement interface can increase propagation loss due to mode conversion and scattering.

The properties of the basement rock are quite important in the shallow water environment, as thin sediments are quite common. For this reason, rather than specifying a reflection coefficient for the underlying basement rock, representative values of the compressional ($v_p$) and shear ($v_s$) speeds and density of the rock are specified, which can be used to calculate a Rayleigh reflection coefficient. The effect of roughness on the reflectivity of basement rock in shallow water is not well understood, and no attempt to characterize it has been attempted. The geo-acoustic areas were developed with the intent that over any given area, the same sequence of geological processes producing deformation of the basement has occurred. Thus the definition of these areas should aid in the extrapolation of observed roughness effects, when determined.

## Section 5
## CONCLUSION

An extension of the BLUG database concept to a shallow water environment of the Korea Strait has been carried out. The Korea Strait is part of a complex trench-arc-back system characteristic of the western margin of the Pacific. A set of geo-acoustic areas has been developed which reflects the complex sedimentation and tectonic processes occurring in the region. Geo-acoustic parameters reflecting this geological analysis have been developed to characterize the acoustic propagation characteristics of the region. It is felt that parameters representing the physical properties of the sediment are appropriate for acoustic modeling purposes. The "stainless steel layer" feature of the original deep-water-BLUG database has been suppressed. Physical properties of the underlying basement rock have been specified as opposed to supplying a single basement reflection coefficient. Effects of bottom roughness have not been treated in the geo-acoustic parametrization of the bottom. However, the definition of the geo-acoustic areas reflects the geographic extent of various roughness regimes, and will aid in the extrapolation of measured roughness effects when they are measured acoustically.

## Section 6
## REFERENCES


1. Batylas, W. E. and Yee, G. S. Fasor I: Basic Long-Range Active Sonar Studies in Western Pacific Areas. U.S. Navy Journal of Underwater Acoustics, Vol. 15, No. 4, October 1965.

2. Belgodere, Carlos and Allan Lowrie. A Geological Interpretation of Acoustic Properties in Korea Strait. NAVOCEANO, July 1980.

3. Clay, C.S. and Medwin, H. Acoustical Oceanography: Principles and Applications. New York. John Wiley and Sons, 1977.

4. Gotthardt, Gerald A. and others. Acoustic Detection Ranges in the Korea Strait (U) SECRET. Technical Report 253, Naval Oceanographic Office, Bay St. Louis, MS, June 1980.

5. Greene, R.R. and C.W. Spofford. Comparisons of NADC Measured Bottom-Loss with BLUG Simulated Bottom Loss. SAI 84-138-WA, McLean, VA. March 1, 1983.

6. Hamilton, E.L. Geoacoustic Modeling of the Sea Floor. J. Acoust. Soc. Am. 68(5), p. 1313-1340, Nov., 1980.

7. Hamilton, Bachman and others. Fasor III: Sea-Floor Studies (U). NUSC, San Diego, Cal., June 1973.

8. Hjulstrom, F., Transportation of Detritus by Moving Water. In Trask, P.D. ed., "Recent Marine Sediments", 5-31. Soc. Econ. Paleont. Mineral., Tulsa, Oklahoma, 1939.

9. Honza, Eiichi, ed. Geological Investigation of the Japan Sea, April-June 1978 (GH 78-2 Cruise). Geological Survey of Japan, 1979.

10. Honza, Eiichi, ed. Geological Investigations in the Northern Margin of Okinawa Trough and the Western Margin of the Japan Sea, April-May 1977 (GH 77-2 Cruise). Geological Survey of Japan, 1978.

11. Ingue, Eiji, ed. Goto-nada Sea and Tsushima Strait Investigations, Northwestern Kyushu, 1972-1973. Geological Survey of Japan, 1975.

12. Karig, D.E., Evolution of Arc Systems in the Western Pacific, Ann. Rev. Earth Planet Sci., 1974.

13. Katsura, Tadahiko and Manao Nagano. Geomorphology and Tectonic Movement of the Sea Floor, Northwest off Kyushu, Japan. Journal of the Oceanographical Society of Japan, Vol. 32, pp. 139 to 150, 1976.

14. Katsura, Tadahiko and Shoji Kitahara. Geological Structure of the Marginal Plateau off Tottori, Southern-west of Honshu, Japan. Journal of the Oceanographical Society of Japan, Vol. 33, No. 5, October 1977.

15. Lowrie, Allen. Areas of Acoustic Basement and Sediment Outlined by the Isopleth Representing .25 seconds. U.S. Naval Oceanographic Office, NSTL Station, MS, 1984.

16. Marine Geology Map Series #3. Bottom Distribution Maps of Recent Sediments. Republic of Korea Army Map Services September 1979.

17. Monet, W.F. et al. Development of Geo-Acoustic Areas for the Bottom-Loss Upgrade. SAI 83-976-WA, McLean, VA. March 1983.

18. Murauchi, Sadanori and Toshio Asanuma. Studies on the Seismic Profiles Records of Sediments on the Continental Shelf East of the Tsushima Islands, Kyushu, Japan. Memoirs of the National Science Museum, No. 2, Ueno Park, Tokyo, Japan, September 1969.

19. Nagano, Sakurai and others. Submarine Geology off West Coast of Kyusyu. Report of Hydrographic Researches, No. 11, March 1976.

20. Niino, Hiroshi and K. O. Emery. Sediments of Shallow Portions of East China Sea and South China Sea. GSA Bulletin, Y72, p. 731-762, May 1961.

21. Palumbo, Joseph X. and others. Shallow Water Transmission Loss - Korea Strait - 1975 (U) SECRET. Technical Note 7300-C1-81, Naval Oceanographic Office, Bay St. Louis, MS. January, 1981.

22. Shepard, F.P., Emery, K.O. and Gould, H.R., Distribution of Sediments on East Asiatic Continental Shelf: Allan Hancock Foundation Occasional Paper 9, 64 p., 1949.

23. Shepard, F.P. Nomenclature Based on Sand-Silt-Clay Ratios. Jour. Sediment. Petrol. 24, 151-158, 1954.

24. Spofford, C.W. et al. The Estimation of Geo-Acoustic Ocean Sediment Parameters from Measured Bottom-Loss Data. SAI 83-879-WA, McLean, VA. March 1983.

25. Talwani, Manik, and Walter C. Pitman III, eds. Island Arcs and Trenches and Back-Arc Basins. American Geophysical Union, Washington, D.C., 1977.

26. Uda, M., On the Fluctuations of the Main Stream Axis and its Boundary Line of Kuroshio: Oceanographic Soc. Japan Jour., V. 6, p. 181-189, 1951.

27. Ujiié, Hiroshi and Takashi Mitsuoka. Preliminary Report on the Topography and Sediments of the Tsushima Straits, Southern Entrance to the Sea of Japan. Memoirs of the National Science Museum No. 2, National Science Museum, Ueno Park, Tokyo, Japan, September 1969.

28. Urick, R.J. Principles of Underwater Sound. New York: McGraw-Hill Book Pa, 1975.

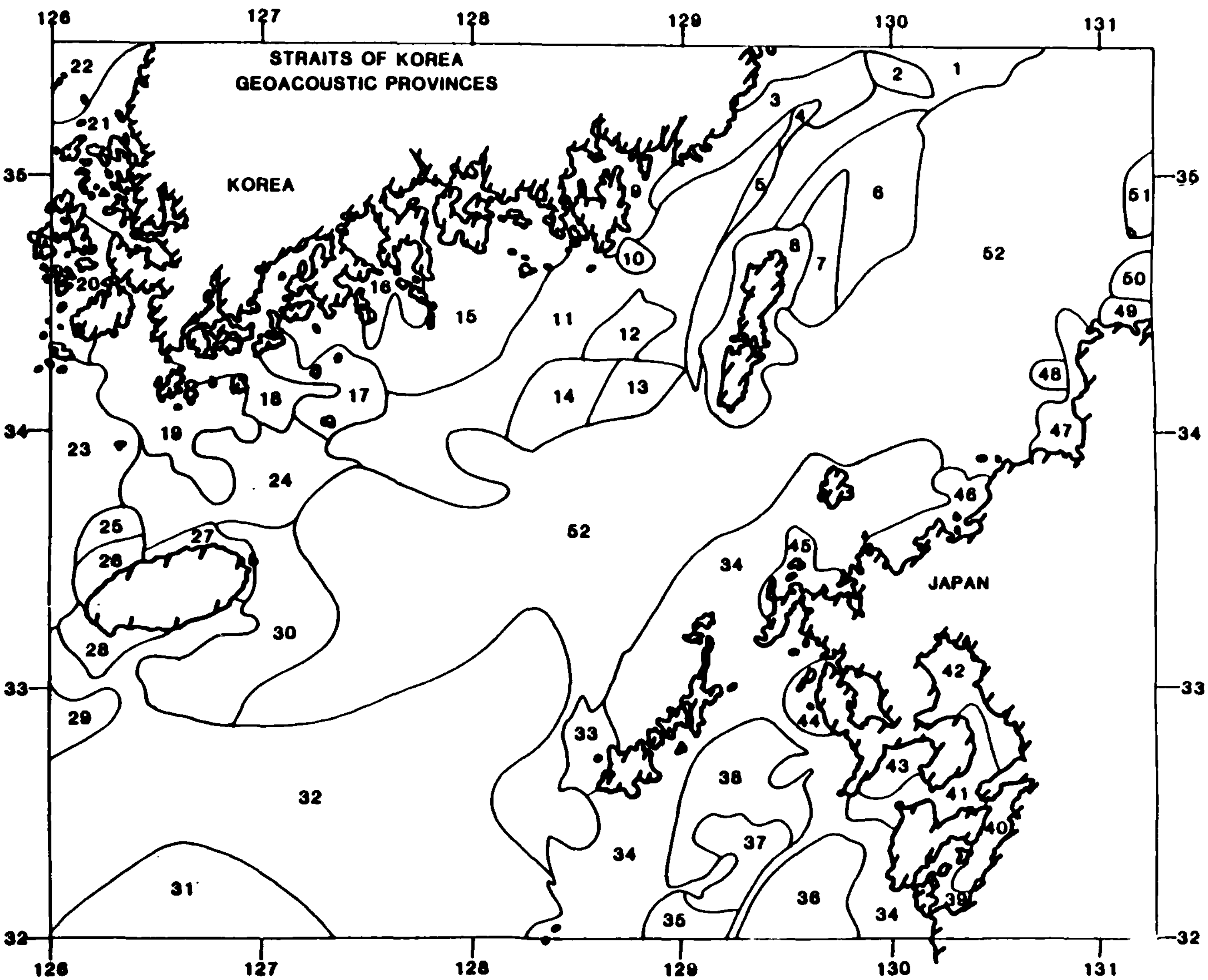
29. Wageman, John W. and others. Structural Framework of East China Sea and Yellow Sea. AAPG, 1970.

30. Wang, C.S., Sand-Fraction Study of the Shelf Sediments off the China Coast: Geol. Soc. of China, Proc., No. 4, p. 33-49, 1961.

31. Whitney, Gordon and others. Evaluation of Surface Ducts in Shallow Water. NOSC Technical Report 763.

# APPENDIX A

## GEOACOUSTIC PROVINCES OF THE KOREA STRAIT




GEOACOUSTIC PROVINCES OF THE KOREA STRAIT

# APPENDIX B

## SUMMARY OF GEOLOGIC PARAMETERS FOR ALL AREAS

## SUMMARY OF GEOLOGIC PARAMETERS

| | GRAIN SIZE | | | | | | | | | | | SED THICK | | | BASE ROUGH | | LAYERING | | BATHY | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SILTY-CLAY | CLAYEY-SILT | SAND-SILT-CLAY | SANDY SILT | SILTY SAND | FINE SAND | COARSE SAND | GRAVELLY SAND | SAND ROCK | GRAVELLY ROCK | ROCK | LITTLE OR NONE | THIN | THICK | SMOOTH | ROUGH | PRESENT | NOT PRESENT | SMOOTH | ROUGH |
| 1 | | | | ● | | | | | | | | | | ● | ● | | ● | | | ● |
| 2 | | | | | | | ● | | | | | | | ● | | ● | | ● | | ● |
| 3 | ● | | | | | | | | | | | | | ● | | ● | | ● | | ● |
| 4 | | | | | ● | | | | | | | | | ● | | ● | | ● | | ● |
| 5 | | | | | | ● | | | | | | | | ● | | ● | | ● | | ● |
| 6 | | | | ● | | | | | | | | | | ● | ● | | ● | | ● | |
| 7 | | | ● | | | | | | | | | | | ● | ● | | ● | | ● | |
| 8 | | | | | | | | | ● | | | ● | | | | ● | | ● | ● | |
| 9 | | | | ● | | | | | | | | | ● | | | ● | | ● | ● | |
| 10 | | | | | | | | | ● | | | ● | | | | ● | | ● | ● | |
| 11 | | | ● | | | | | | | | | | ● | | | ● | | ● | ● | |
| 12 | ● | | | | | | | | | | | | ● | | | ● | | ● | ● | |
| 13 | | | | | | | ● | | | | | | | ● | | ● | | ● | | ● |
| 14 | | | | | ● | | | | | | | | ● | | | ● | | ● | ● | |
| 15 | ● | | | | | | | | | | | | ● | | | ● | | ● | ● | |
| 16 | | | | | | | | | ● | | | | | | | ● | | ● | ● | |
| 17 | | | | | | | | | ● | | | ● | | | | ● | | ● | | ● |
| 18 | | | ● | | | | | | | | | | ● | | | ● | | ● | | ● |
| 19 | | | | | | | | ● | | | | | ● | | | ● | | ● | | ● |
| 20 | | | | | | | ● | | | | | | ● | | | ● | | ● | | ● |
| 21 | | | ● | | | | | | | | | | ● | | | ● | | ● | | ● |
| 22 | | | | | | | | | ● | | | ● | | | | ● | | ● | | ● |
| 23 | | | ● | | | | | | | | | | | ● | | ● | | ● | | ● |
| 24 | | | | | | | ● | | | | | | | ● | | ● | | ● | ● | |
| 25 | | | | | | | | ● | | | | | ● | | | ● | | ● | | ● |
| 26 | | ● | | | | | | | | | | | ● | | | ● | | ● | | ● |
| 27 | | | | | | | | | ● | | | ● | | | | ● | | ● | | ● |
| 28 | | | | | | | | | ● | | | ● | | | | ● | | ● | | ● |
| 29 | ● | | | | | | | | | | | | | ● | | ● | ● | | ● | |
| 30 | | | ● | | | | | | | | | | | ● | | ● | ● | | ● | |
| 31 | | | ● | | | | | | | | | | | ● | | ● | ● | | | ● |
| 32 | | | | | | ● | | | | | | | ● | | | ● | ● | | | ● |
| 33 | | | | | | | | | | ● | | ● | | | | ● | | ● | ● | |
| 34 | | | | | | | | | ● | | | ● | | | | ● | | ● | ● | |
| 35 | | | | | | ● | | | | | | | | ● | | ● | | ● | | ● |
| 36 | | | | | | ● | | | | | | | | ● | | ● | | ● | | ● |
| 37 | | | ● | | | | | | | | | | ● | | | ● | | ● | | ● |
| 38 | | | | | | ● | | | | | | | ● | | | ● | | ● | ● | |
| 39 | | | | | | | | ● | | | | | ● | | | ● | | ● | | ● |
| 40 | ● | | | | | | | | | | | | ● | | | ● | | ● | | ● |
| 41 | | | | | | | | ● | | | | | ● | | | ● | | ● | | ● |
| 42 | | | ● | | | | | | | | | | ● | | | ● | | ● | | ● |
| 43 | | | ● | | | | | | | | | ● | | | | ● | | ● | | ● |
| 44 | | | | | | | | | | | ● | ● | | | | ● | | ● | | ● |
| 45 | | | | | | | | | | ● | | ● | | | | ● | | ● | | ● |
| 46 | | | | | | | | | | ● | | ● | | | | ● | | ● | | ● |
| 47 | | | | | | | | | | ● | | ● | | | | ● | | ● | | ● |
| 48 | | | ● | | | | | | | | | | ● | | | ● | ● | | | ● |
| 49 | | | | | | | | | | ● | | ● | | | | ● | | ● | | ● |
| 50 | | | ● | | | | | | | | | | | ● | | ● | ● | | ● | |
| 51 | | | | | | | | | ● | | | ● | | | | ● | | ● | ● | |
| 52 | | | | | | | ● | | | | | | | ● | | ● | ● | | ● | |

# APPENDIX C

## PARTITIONING OF GEOACOUSTIC AREAS WITH A DEPENDENCE ON SEDIMENT THICKNESS

PARTITIONING OF AREAS BASED ON SEDIMENT THICKNESS, BASEMENT ROUGHNESS AND GRAIN SIZE

SEDIMENT THICKNESS

| NONE | | THIN | | THICK | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| BASEMENT ROUGHNESS | | BASEMENT ROUGHNESS | | GRAIN SIZE | | | | | | |
| ROUGH | SMOOTH | ROUGH | SMOOTH | SC | CS | SSC | S-SLT | SLT-S | FINE SAND | CRS SAND |
| 8 | | 9 | | 3 | | 7 | 1 | 4 | 5 | 2 |
| 10 | | 11 | | 29 | | 23 | 6 | | 35 | 13 |
| 17 | | 12 | | | | 30 | | | 36 | 24 |
| 22 | | 14 | | | | 31 | | | | 52 |
| 27 | | 15 | | | | 50 | | | | |
| 28 | | 18 | | | | | | | | |
| 33 | | 19 | | | | | | | | |
| 34 | | 20 | | | | | | | | |
| 43 | | 21 | | | | | | | | |
| 44 | | 25 | | | | | | | | |
| 45 | | 26 | | | | | | | | |
| 46 | | 32 | | | | | | | | |
| 47 | | 37 | | | | | | | | |
| 49 | | 38 | | | | | | | | |
| 51 | | 39 | | | | | | | | |
| | | 40 | | | | | | | | |
| | | 41 | | | | | | | | |
| | | 42 | | | | | | | | |
| | | 48 | | | | | | | | |

# APPENDIX D

## GEOACOUSTIC PROVINCE AREA SHEETS FOR THE KOREA STRAIT

## Area #1

Surface Sediment Type: Terrigenous
Grain Size: Sand-Silt-Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
- _ Little or No Sediment
- _ Thin (0-.25 sec. TWTT)
- ✓ Thick (> .25 sec. TWTT)

Basement Roughness:
- ✓ Smooth
- _ Rough

Surface Layering: (i.e., Turbidites)
- ✓ Present
- _ Not Present

Bathymetry:
- ✓ Rough
- _ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | ✓ | |
| Surface Layering | | ✓ | |
| Bathymetry | ✓ | | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 1.033 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.596

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.596

**Basement**

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #2

Surface Sediment Type: Terrigenous
Grain Size: Coarse Sand
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
✓ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
✓ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | ✓ | |
| Basement Roughness | | | ✓ |
| Surface Layering | | ✓ | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 1.201 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.034

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.034

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

## Area #3

Surface Sediment Type: Terrigenous
Grain Size: Silty Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
- _ Little or No Sediment
- _ Thin (0-.25 sec. TWTT)
- ✓ Thick (> .25 sec. TWTT)

Basement Roughness:
- _ Smooth
- ✓ Rough

Surface Layering: (i.e., Turbidites)
- _ Present
- ✓ Not Present

Bathymetry:
- ✓ Rough
- _ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | | |
| Basement Roughness | | | ✓ |
| Surface Layering | | ✓ | |
| Bathymetry | ✓ | | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: .994 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.421

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.421

**Basement**

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #4

Surface Sediment Type: Terrigenous
Grain Size: Silty Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
✓ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
✓ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | ✓ | |
| Basement Roughness | | | ✓ |
| Surface Layering | | ✓ | |
| Bathymetry | ✓ | | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 1.078  Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ (dB/$m^2$/kHz): -.0006

Density — $\rho_3$ (g/$cm^3$): 1.772

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ (g/$cm^3$): 1.772

Basement

Density — (g/$cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

## Area #5

Surface Sediment Type: Terrigenous
Grain Size: Fine Sand
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
√ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
√ Rough

Surface Layering: (i.e., Turbidites)
_ Present
√ Not Present

Bathymetry:
√ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | √ | | |
| Sediment Thickness | | √ | |
| Basement Roughness | | | √ |
| Surface Layering | | √ | |
| Bathymetry | √ | | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 1.145 Grad($g_o$) (sec$^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ (dB/m$^2$/kHz): -.0006

Density — $\rho_3$ (g/cm$^3$): 1.941

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ (g/cm$^3$): 1.941

Basement

Density — (g/cm$^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #6

Surface Sediment Type: Terrigenous
Grain Size: Sandy Silt
Bulk Sediment Type: Terrigenous

Sediment Thickness:
- _ Little or No Sediment
- _ Thin (0-.25 sec. TWTT)
- ✓ Thick (> .25 sec. TWTT)

Basement Roughness:
- ✓ Smooth
- _ Rough

Surface Layering: (i.e., Turbidites)
- ✓ Present
- _ Not Present

Bathymetry:
- _ Rough
- ✓ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | ✓ | |
| Surface Layering | | ✓ | |
| Bathymetry | ✓ | | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 1.080 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.771

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.771

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #7

Surface Sediment Type: Terrigenous
Grain Size: Fine Sand
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
✓ Thick (> .25 sec. TWTT)

Basement Roughness:
✓ Smooth
_ Rough

Surface Layering: (i.e., Turbidites)
✓ Present
_ Not Present

Bathymetry:
_ Rough
✓ Smooth

| | EXTENT OF DATA SOURCES | | |
|---|---|---|---|
| | Adequate | Limited | None |
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | ✓ | |
| Surface Layering | | ✓ | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 1.145 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.941

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.941

**Basement**

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #8

Surface Sediment Type: Terrigenous
Grain Size: Sand/Rock
Bulk Sediment Type: Rock

Sediment Thickness:
✓ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
_ Rough
✓ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | | ✓ |
| Surface Layering | ✓ | | |
| Bathymetry | ✓ | | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 3.43 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.73

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.73

**Basement**

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

## Area #9

Surface Sediment Type: Terrigenous
Grain Size: Sandy Silt
Bulk Sediment Type: Terrigenous

Sediment Thickness:
- _ Little or No Sediment
- √ Thin (0-.25 sec. TWTT)
- _ Thick (> .25 sec. TWTT)

Basement Roughness:
- _ Smooth
- √ Rough

Surface Layering: (i.e., Turbidites)
- _ Present
- √ Not Present

Bathymetry:
- _ Rough
- √ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | √ | | |
| Sediment Thickness | | | √ |
| Basement Roughness | | | √ |
| Surface Layering | | √ | |
| Bathymetry | √ | | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 1.080 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.771

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.771

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #10

Surface Sediment Type: Terrigenous
Grain Size: Sand/Rock
Bulk Sediment Type: Rock

Sediment Thickness:
✓ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
_ Rough
✓ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | | ✓ |
| Surface Layering | ✓ | | |
| Bathymetry | ✓ | | |

Geoacoustic Parameters:

__Bulk__

Sound Speed Profile — Ratio: 3.43 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.73

__Thin Layer__

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.73

__Basement__

Density — ($g/cm^3$): 2.726
$v_p$ (m/s): 5170
$v_s$ (m/s): 2720

## Area #11

Surface Sediment Type: Terrigenous
Grain Size: Sand Silt Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
- _ Little or No Sediment
- ✓ Thin (0-.25 sec. TWTT)
- _ Thick (> .25 sec. TWTT)

Basement Roughness:
- _ Smooth
- ✓ Rough

Surface Layering: (i.e., Turbidites)
- _ Present
- ✓ Not Present

Bathymetry:
- _ Rough
- ✓ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | | ✓ |
| Basement Roughness | | | ✓ |
| Surface Layering | | ✓ | |
| Bathymetry | ✓ | | |

Geoacoustic Parameters:

<u>Bulk</u>

Sound Speed Profile — Ratio: 1.033 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.596

<u>Thin Layer</u>

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.596

<u>Basement</u>

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #12

Surface Sediment Type: Terrigenous
Grain Size: Silty Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
✓ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
_ Rough
✓ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | | ✓ |
| Basement Roughness | | | ✓ |
| Surface Layering | | ✓ | |
| Bathymetry | ✓ | | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: .994 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.421

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.421

*Basement*

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #13

Surface Sediment Type: Terrigenous
Grain Size: Coarse Sand
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
✓ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
✓ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | | ✓ |
| Surface Layering | | ✓ | |
| Bathymetry | ✓ | | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 1.201 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.034

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.034

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

## Area #14

Surface Sediment Type: Terrigenous
Grain Size: Silty Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
√ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
√ Rough

Surface Layering: (i.e., Turbidites)
_ Present
√ Not Present

Bathymetry:
_ Rough
√ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | √ | | |
| Sediment Thickness | | | √ |
| Basement Roughness | | | √ |
| Surface Layering | | √ | |
| Bathymetry | √ | | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 1.078 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.772

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.772

**Basement**

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #15

Surface Sediment Type: Terrigenous
Grain Size: Silty Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
- _ Little or No Sediment
- ✓ Thin (0-.25 sec. TWTT)
- _ Thick (> .25 sec. TWTT)

Basement Roughness:
- _ Smooth
- ✓ Rough

Surface Layering: (i.e., Turbidites)
- _ Present
- ✓ Not Present

Bathymetry:
- _ Rough
- ✓ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | | ✓ |
| Basement Roughness | | | ✓ |
| Surface Layering | | ✓ | |
| Bathymetry | ✓ | | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: .994 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.421

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.421

**Basement**

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #16

Surface Sediment Type: Terrigenous
Grain Size: Sand/Rock
Bulk Sediment Type: Rock

Sediment Thickness:
✓ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
_ Rough
✓ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | | ✓ |
| Surface Layering | ✓ | | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 3.43 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.73

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.73

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #17

Surface Sediment Type: Terrigenous
Grain Size: Sand/Rock
Bulk Sediment Type: Rock

Sediment Thickness:
✓ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
✓ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | | ✓ |
| Surface Layering | ✓ | | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 3.43 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.73

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.73

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #18

Surface Sediment Type: Terrigenous
Grain Size: Sand Silt Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
✓ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
✓ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | | ✓ |
| Basement Roughness | | | ✓ |
| Surface Layering | | ✓ | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 1.033 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.596

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.596

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #19

Surface Sediment Type: Terrigenous
Grain Size: Gravelly Sand
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
√ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
√ Rough

Surface Layering: (i.e., Turbidites)
_ Present
√ Not Present

Bathymetry:
√ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | √ | | |
| Sediment Thickness | | | √ |
| Basement Roughness | | | √ |
| Surface Layering | | √ | |
| Bathymetry | | √ | |

Geoacoustic Parameters:

<u>Bulk</u>

Sound Speed Profile — Ratio: 1.30 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.10

<u>Thin Layer</u>

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.10

<u>Basement</u>

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #20

Surface Sediment Type: Terrigenous
Grain Size: Coarse Sand
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
✓ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
✓ Rough
_ Smooth

| | EXTENT OF DATA SOURCES | | |
|---|---|---|---|
| | Adequate | Limited | None |
| Sediment Type | ✓ | | |
| Sediment Thickness | | | ✓ |
| Basement Roughness | | | ✓ |
| Surface Layering | | ✓ | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 1.201 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.034

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.034

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #21

Surface Sediment Type: Terrigenous
Grain Size: Sand Silt Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
✓ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
✓ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | | ✓ |
| Basement Roughness | | | ✓ |
| Surface Layering | | ✓ | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 1.033 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.596

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.596

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #22

Surface Sediment Type: Terrigenous
Grain Size: Sand/Rock
Bulk Sediment Type: Rock

Sediment Thickness:
- ✓ Little or No Sediment
- _ Thin (0-.25 sec. TWTT)
- _ Thick (> .25 sec. TWTT)

Basement Roughness:
- _ Smooth
- ✓ Rough

Surface Layering: (i.e., Turbidites)
- _ Present
- ✓ Not Present

Bathymetry:
- ✓ Rough
- _ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | | ✓ |
| Surface Layering | ✓ | | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 3.43 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.73

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.73

**Basement**

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #23

Surface Sediment Type: Terrigenous
Grain Size: Sand Silt Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
√ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
√ Rough

Surface Layering: (i.e., Turbidites)
_ Present
√ Not Present

Bathymetry:
√ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | √ | | |
| Sediment Thickness | | | √ |
| Basement Roughness | | | √ |
| Surface Layering | | √ | |
| Bathymetry | | √ | |

Geoacoustic Parameters:

<u>Bulk</u>

Sound Speed Profile — Ratio: 1.033 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.596

<u>Thin Layer</u>

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.596

<u>Basement</u>

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #24

Surface Sediment Type: Terrigenous
Grain Size: Coarse Sand
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
√ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
√ Rough

Surface Layering: (i.e., Turbidites)
_ Present
√ Not Present

Bathymetry:
_ Rough
√ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | √ | | |
| Sediment Thickness | | | √ |
| Basement Roughness | | | √ |
| Surface Layering | | √ | |
| Bathymetry | | √ | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 1.201 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ (dB/$m^2$/kHz): -.0006

Density — $\rho_3$ (g/$cm^3$): 2.034

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ (g/$cm^3$): 2.034

**Basement**

Density — (g/$cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #25

Surface Sediment Type: Terrigenous
Grain Size: Gravelly Sand
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
✓ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
✓ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | | ✓ |
| Basement Roughness | | | ✓ |
| Surface Layering | | ✓ | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

<u>Bulk</u>

Sound Speed Profile — Ratio: 1.30 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.10

<u>Thin Layer</u>

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.10

<u>Basement</u>

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #26

Surface Sediment Type: Terrigenous
Grain Size: Clayey Silt
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
✓ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
✓ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | | ✓ |
| Basement Roughness | | | ✓ |
| Surface Layering | | ✓ | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 1.014 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.488

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.488

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #27

Surface Sediment Type: Terrigenous
Grain Size: Sand/Rock
Bulk Sediment Type: Rock

Sediment Thickness:
- ✓ Little or No Sediment
- _ Thin (0-.25 sec. TWTT)
- _ Thick (> .25 sec. TWTT)

Basement Roughness:
- _ Smooth
- ✓ Rough

Surface Layering: (i.e., Turbidites)
- _ Present
- ✓ Not Present

Bathymetry:
- ✓ Rough
- _ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | | ✓ |
| Surface Layering | ✓ | | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 3.43 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.73

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.73

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #28

Surface Sediment Type: Terrigenous
Grain Size: Sand/Rock
Bulk Sediment Type: Rock

Sediment Thickness:
✓ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
✓ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | | ✓ |
| Surface Layering | ✓ | | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 3.43 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.73

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.73

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

## Area #29

Surface Sediment Type: Terrigenous
Grain Size: Silt Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
✓ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
✓ Present
_ Not Present

Bathymetry:
_ Rough
✓ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | ✓ | |
| Basement Roughness | | | ✓ |
| Surface Layering | | ✓ | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: .994 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ (dB/$m^2$/kHz): -.0006

Density — $\rho_3$ (g/$cm^3$): 1.421

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ (g/$cm^3$): 1.421

**Basement**

Density — (g/$cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #30

Surface Sediment Type: Terrigenous
Grain Size: Sand Silt Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
✓ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
✓ Present
_ Not Present

Bathymetry:
_ Rough
✓ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | ✓ | |
| Basement Roughness | | | ✓ |
| Surface Layering | | ✓ | |
| Bathymetry | ✓ | | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 1.033 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.596

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.596

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #31

Surface Sediment Type: Terrigenous
Grain Size: Sand Silt Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
✓ Thick (> .25 sec. TWTT)

Basement Roughness:
Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
✓ Present
_ Not Present

Bathymetry:
✓ Rough
_ Smooth

| | EXTENT OF DATA SOURCES | | |
|---|---|---|---|
| | Adequate | Limited | None |
| Sediment Type | ✓ | | |
| Sediment Thickness | | ✓ | |
| Basement Roughness | ✓ | | |
| Surface Layering | | ✓ | |
| Bathymetry | ✓ | | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 1.033 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ (dB/$m^2$/kHz): -.0006

Density — $\rho_3$ (g/$cm^3$): 1.596

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ (g/$cm^3$): 1.596

**Basement**

Density — (g/$cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #32

Surface Sediment Type: Terrigenous
Grain Size: Fine Sand
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
√ Thin (0-.25 sec. TWTT)
√ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
√ Rough

Surface Layering: (i.e., Turbidites)
√ Present
_ Not Present

Bathymetry:
√ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | √ | | |
| Sediment Thickness | √ | | |
| Basement Roughness | √ | | |
| Surface Layering | | √ | |
| Bathymetry | √ | | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 1.145 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.941

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.941

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #33

Surface Sediment Type: Terrigenous
Grain Size: Gravel/Rock
Bulk Sediment Type: Rock

Sediment Thickness:
✓ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
_ Rough
✓ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | ✓ | |
| Surface Layering | ✓ | | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 3.43 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.73

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.73

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #34

Surface Sediment Type: Terrigenous
Grain Size: Sand/Rock
Bulk Sediment Type: Rock

Sediment Thickness:
√ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
√ Rough

Surface Layering: (i.e., Turbidites)
_ Present
√ Not Present

Bathymetry:
_ Rough
√ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | √ | | |
| Sediment Thickness | √ | | |
| Basement Roughness | √ | | |
| Surface Layering | √ | | |
| Bathymetry | √ | | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 3.43 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.73

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.73

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #35

Surface Sediment Type: Terrigenous
Grain Size: Fine Sand
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
√ Thin (0-.25 sec. TWTT)
√ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
√ Rough

Surface Layering: (i.e., Turbidites)
_ Present
√ Not Present

Bathymetry:
√ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | √ | | |
| Sediment Thickness | √ | | |
| Basement Roughness | √ | | |
| Surface Layering | | | √ |
| Bathymetry | √ | | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 1.145 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.941

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.941

**Basement**

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #36

Surface Sediment Type: Terrigenous
Grain Size: Fine Sand
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
✓ Thin (0-.25 sec. TWTT)
✓ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
✓ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | ✓ | | |
| Surface Layering | | | ✓ |
| Bathymetry | ✓ | | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 1.145 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.941

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.941

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #37

Surface Sediment Type: Terrigenous
Grain Size: Sand Silt Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
√ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
√ Rough

Surface Layering: (i.e., Turbidites)
_ Present
√ Not Present

Bathymetry:
_ Rough
√ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | √ | | |
| Sediment Thickness | √ | | |
| Basement Roughness | √ | | |
| Surface Layering | | | √ |
| Bathymetry | √ | | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 1.033 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.596

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.596

**Basement**

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #38

Surface Sediment Type: Terrigenous
Grain Size: Fine Sand
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
✓ Thin (0-.25 sec. TWTT)
✓ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
_ Rough
✓ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | ✓ | | |
| Surface Layering | | | ✓ |
| Bathymetry | ✓ | | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 1.145 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.941

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.941

**Basement**

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #39

Surface Sediment Type: Terrigenous
Grain Size: Gravelly Sand
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
✓ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
✓ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | | ✓ |
| Basement Roughness | | ✓ | |
| Surface Layering | | | ✓ |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 1.3 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.10

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.10

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #40

Surface Sediment Type: Terrigenous
Grain Size: Silty Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
✓ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
✓ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | | ✓ |
| Basement Roughness | | ✓ | |
| Surface Layering | | | ✓ |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: .994 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ (dB/m$^2$/kHz): -.0006

Density — $\rho_3$ (g/cm$^3$): 1.421

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ (g/cm$^3$): 1.421

**Basement**

Density — (g/cm$^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

## Area #41

Surface Sediment Type: Terrigenous
Grain Size: Gravelly Sand
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
✓ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
✓ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | ✓ | |
| Surface Layering | | | ✓ |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 1.30 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ (dB/$m^2$/kHz): -.0006

Density — $\rho_3$ (g/$cm^3$): 2.10

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ (g/$cm^3$): 2.10

**Basement**

Density — (g/$cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #42

Surface Sediment Type: Terrigenous
Grain Size: Sand Silt Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
✓ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
✓ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | ✓ | |
| Basement Roughness | | ✓ | |
| Surface Layering | | | ✓ |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 1.033 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.596

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.596

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #43

Surface Sediment Type: Terrigenous
Grain Size: Sand Silt Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
- ✓ Little or No Sediment
- _ Thin (0-.25 sec. TWTT)
- _ Thick (> .25 sec. TWTT)

Basement Roughness:
- _ Smooth
- ✓ Rough

Surface Layering: (i.e., Turbidites)
- _ Present
- ✓ Not Present

Bathymetry:
- ✓ Rough
- _ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | ✓ | |
| Surface Layering | | | ✓ |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 1.033 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ (dB/$m^2$/kHz): -.0006

Density — $\rho_3$ (g/$cm^3$): 1.596

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ (g/$cm^3$): 1.596

**Basement**

Density — (g/$cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #44

Surface Sediment Type: Rock
Grain Size:
Bulk Sediment Type: Rock

Sediment Thickness:
- ✓ Little or No Sediment
- _ Thin (0-.25 sec. TWTT)
- _ Thick (> .25 sec. TWTT)

Basement Roughness:
- _ Smooth
- ✓ Rough

Surface Layering: (i.e., Turbidites)
- _ Present
- ✓ Not Present

Bathymetry:
- ✓ Rough
- _ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | ✓ | |
| Surface Layering | ✓ | | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 3.43 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.73

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.73

**Basement**

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #45

Surface Sediment Type: Terrigenous
Grain Size: Gravel/Rock
Bulk Sediment Type: Rock

Sediment Thickness:
- ✓ Little or No Sediment
- _ Thin (0-.25 sec. TWTT)
- _ Thick (> .25 sec. TWTT)

Basement Roughness:
- _ Smooth
- ✓ Rough

Surface Layering: (i.e., Turbidites)
- _ Present
- ✓ Not Present

Bathymetry:
- ✓ Rough
- _ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | ✓ | |
| Surface Layering | ✓ | | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 3.43 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ (dB/$m^2$/kHz): -.0006

Density — $\rho_3$ (g/$cm^3$): 2.73

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ (g/$cm^3$): 2.73

**Basement**

Density — (g/$cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

AD-A164 729 BOTTOM LOSS UPGRADE (BLUG) EXTENSIONS TO STRATEGIC SHALLOW WATER AREAS: K..(U) SCIENCE APPLICATIONS INTERNATIONAL CORP MCLEAN VA W F MONET ET AL. SEP 85 2/2

UNCLASSIFIED SAIC-85/1825 N00014-84-C-0180 F/G 20/1 NL

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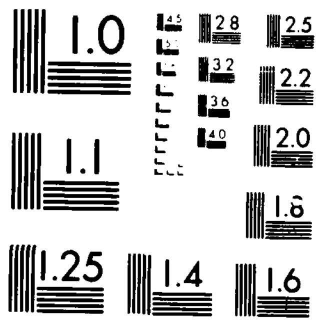


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Area #46

Surface Sediment Type: Terrigenous
Grain Size: Gravel/Rock
Bulk Sediment Type: Rock

Sediment Thickness:
✓ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
_ Present
✓ Not Present

Bathymetry:
✓ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | ✓ | |
| Surface Layering | ✓ | | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 3.43 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.73

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.73

Basement

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #47

Surface Sediment Type: Terrigenous
Grain Size: Gravel/Rock
Bulk Sediment Type: Rock

Sediment Thickness:
- ✓ Little or No Sediment
- _ Thin (0-.25 sec. TWTT)
- _ Thick (> .25 sec. TWTT)

Basement Roughness:
- _ Smooth
- ✓ Rough

Surface Layering: (i.e., Turbidites)
- _ Present
- ✓ Not Present

Bathymetry:
- ✓ Rough
- _ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | ✓ | |
| Surface Layering | ✓ | | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

<u>Bulk</u>

Sound Speed Profile — Ratio: 3.43 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.73

<u>Thin Layer</u>

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.73

<u>Basement</u>

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #48

Surface Sediment Type: Terrigenous
Grain Size: Sand Silt Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
✓ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
✓ Present
_ Not Present

Bathymetry:
✓ Rough
_ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | ✓ | |
| Basement Roughness | | ✓ | |
| Surface Layering | | ✓ | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 1.033 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.596

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.596

**Basement**

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #49

Surface Sediment Type: Terrigenous
Grain Size: Gravel/Rock
Bulk Sediment Type: Rock

Sediment Thickness:
- ✓ Little or No Sediment
- _ Thin (0-.25 sec. TWTT)
- _ Thick (> .25 sec. TWTT)

Basement Roughness:
- _ Smooth
- ✓ Rough

Surface Layering: (i.e., Turbidites)
- _ Present
- ✓ Not Present

Bathymetry:
- ✓ Rough
- _ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | ✓ | |
| Surface Layering | ✓ | | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 3.43 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 2.73

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 2.73

**Basement**

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #50

Surface Sediment Type: Terrigenous
Grain Size: Sand Silt Clay
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
✓ Thin (0-.25 sec. TWTT)
✓ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
✓ Present
_ Not Present

Bathymetry:
_ Rough
✓ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | | | ✓ |
| Basement Roughness | | ✓ | |
| Surface Layering | | ✓ | |
| Bathymetry | | ✓ | |

Geoacoustic Parameters:

**Bulk**

Sound Speed Profile — Ratio: 1.033 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ ($dB/m^2/kHz$): -.0006

Density — $\rho_3$ ($g/cm^3$): 1.596

**Thin Layer**

Thickness — D (m): .04
Density — $\rho_2$ ($g/cm^3$): 1.596

**Basement**

Density — ($g/cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #51

Surface Sediment Type: Terrigenous
Grain Size: Sand/Rock
Bulk Sediment Type: Rock

Sediment Thickness:
√ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
_ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
√ Rough

Surface Layering: (i.e., Turbidites)
_ Present
√ Not Present

Bathymetry:
_ Rough
√ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | √ | | |
| Sediment Thickness | √ | | |
| Basement Roughness | | √ | |
| Surface Layering | √ | | |
| Bathymetry | | √ | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 3.43 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ (dB/$m^2$/kHz): -.0006

Density — $\rho_3$ (g/$cm^3$): 2.73

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ (g/$cm^3$): 2.73

Basement

Density — (g/$cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

Area #52

Surface Sediment Type: Terrigenous
Grain Size: Gravelly Sand
Bulk Sediment Type: Terrigenous

Sediment Thickness:
_ Little or No Sediment
_ Thin (0-.25 sec. TWTT)
✓ Thick (> .25 sec. TWTT)

Basement Roughness:
_ Smooth
✓ Rough

Surface Layering: (i.e., Turbidites)
✓ Present
_ Not Present

Bathymetry:
_ Rough
✓ Smooth

EXTENT OF DATA SOURCES

| | Adequate | Limited | None |
|---|---|---|---|
| Sediment Type | ✓ | | |
| Sediment Thickness | ✓ | | |
| Basement Roughness | | ✓ | |
| Surface Layering | ✓ | | |
| Bathymetry | ✓ | | |

Geoacoustic Parameters:

Bulk

Sound Speed Profile — Ratio: 1.25 Grad($g_o$) ($sec^{-1}$): 20
Curv($\beta$): -.97

Attenuation Profile — $k_o$ (dB/m/kHz): .3
$k_o'$ (dB/$m^2$/kHz): -.0006

Density — $\rho_3$ (g/$cm^3$): 2.12

Thin Layer

Thickness — D (m): .04
Density — $\rho_2$ (g/$cm^3$): 2.12

Basement

Density — (g/$cm^3$): 2.726
— $v_p$ (m/s): 5170
— $v_s$ (m/s): 2720

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